EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANIZATION

RECORD OF RESEARCH

for the period

1st January to 31st December, 1958

ANNUAL REPORT, 1958

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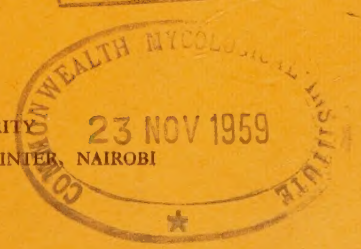

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THE STAFF OF THE EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANIZATION AT THE 31st DECEMBER, 1958

DIRECTORATE

E. W. Russell, M.A., PH.D., F.INST.P. . . . . *Director*
H. C. Pereira, B.SC., PH.D. . . . . *Deputy Director*

RESEARCH DIVISIONS

ANIMAL HUSBANDRY:

W. J. A. Payne, M.A., PH.D., DIP. AGRIC. SC. . . *Officer-in-Charge*
D. W. Duthie, M.A., B.SC., PH.D., F.R.I.C. . . . *Biochemist*

CHEMISTRY:

H. F. Birch, B.SC., PH.D. . . . . *Chemist-in-Charge*
Mrs. C. C. Hood, B.SC. . . . . *Scientific Assistant*
Paul Mungai . . . . . *Laboratory Assistant*

GENERAL CHEMICAL ANALYSIS:

M. T. Friend, M.SC., A.R.I.C. . . . . *General Chemical Analyst*
Leonard Nganga . . . . . *Laboratory Assistant*

SPECTROCHEMISTRY:

G. T. Chamberlain . . . . . *Spectrochemist*
A. J. Searle . . . . . *Scientific Assistant*
C. A. Spinage . . . . . *Scientific Assistant*

ECOLOGY:

C. G. Trapnell, O.B.E., B.A. . . . . *Ecologist*

FORESTRY:

A. L. Griffith, O.B.E., M.A., D.SC. . . . . *Silviculturist-in-Charge*
P. Howland . . . . . *Scientific Assistant*
Joseph Wanyoike . . . . . *Laboratory Assistant*
Evanson Ndungu . . . . . *Laboratory Assistant*
Amos Wanene . . . . . *Laboratory Assistant*
Ernest Warari Muregi . . . . . *Overseer*

FOREST ENTOMOLOGY:

W. Wilkinson, B.SC., M.I.BIOL. . . . . *Forest Entomologist*

MICROBIOLOGY:

J. W. Millbank, B.SC., PH.D. . . . . *Microbiologist*
Mrs. M. A. Ledger, N.D.D. . . . . *Scientific Assistant*
Chege Mugane . . . . . *Laboratory Assistant*

NEMATOLOGY:

A. G. Whitehead, B.SC., A.R.C.S. . . . . *Nematologist*

PHYSICS:

(H. C. Pereira, B.SC., PH.D.) . . . . . *Physicist-in-Charge*
O. Kerfoot, B.A., B.SC. . . . . *Silviculturist*
J. S. G. McCulloch, B.SC., PH.D., A.INST.P. . . *Agricultural Meteorologist*
M. Dagg, B.SC., PH.D. . . . . *Soil Physicist*
P. H. Hosegood . . . . . *Scientific Assistant*

J. W. Simmons	*Scientific Assistant*
Ezekiel Kasavuli	*Senior Observer*
Stephen Ngethe	*Laboratory Assistant*
Augustino Waratho Charles	*Laboratory Assistant*
Francis Mbugwa	*Laboratory Assistant*
Jacob Mudianga	*Laboratory Assistant*
Wallace Gichuru	*Laboratory Assistant*

PLANT BREEDING AND GENETICS:

L. R. Doughty, B.SC. (AGRIC.), N.D.A.	*Geneticist*
H. Doggett, M.A., A.I.C.T.A.	*Plant Breeder*
T. Graham	*Agricultural Assistant*
Barnabas Kifua	*Laboratory Assistant*

PLANT PATHOLOGY:

H. H. Storey, C.M.G., M.A., PH.D., F.R.S.	*Pathologist-in-Charge*
Miss F. M. L. Sheffield, D.SC.	*Plant Pathologist*
Mrs. A. K. Howland, B.SC.	*Scientific Assistant*
Ferdinand Wamagata	*Laboratory Assistant*
Geoffrey Kuria	*Laboratory Assistant*

PLANT PHYSIOLOGY:

J. Glover, M.SC.	*Plant Physiologist*
Henry Thuku Rimi	*Laboratory Assistant*
Edward Stephen Waweru	*Laboratory Assistant*

SOIL SURVEY:

R. M. Scott, B.SC.	*Soil Surveyor*

SYSTEMATIC BOTANY:

B. Verdcourt, B.SC., PH.D.	*Botanist-in-Charge of the E.A. Herbarium*
Miss D. M. Napper, B.SC.	*Scientific Assistant*
J. G. B. Newbould, B.A.	*Scientific Assistant*
George Williams	*Laboratory Assistant*
Edward P. K. Kaya	*Laboratory Assistant*
Petro C. Owite	*Clerk*

AGRICULTURE AND FORESTRY SERVICES

HORTICULTURE AND NURSERY:

W. B. May, F.R.H.S.	*Horticulturist*
Angel Gathara	*Overseer*

MUGUGA SOUTH FARM

H. P. Ledger, N.D.D.	*Farm Manager*
A. F. Dent, DIP. AGRIC., DIP. DAIRYING	*Assistant Farm Manager*
Nelson Mwangi	*Recorder*
Mayda Kapitapa	*Overseer*

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY:

Mrs. L. Verdcourt, A.L.A.	*Librarian*
Mrs. J. U. Ferris	*Assistant Librarian*
Daniel Lazarus	*Assistant Librarian*
Joseph Okakah	*Bookbinder*

THE EAST AFRICAN AGRICULTURAL JOURNAL:

(D. W. Duthie, M.A., B.SC., PH.D., F.R.I.C.)	*Editor*
Mrs. P. D. Hosegood	*Assistant Editor*

THE EAST AFRICAN PLANT QUARANTINE STATION:

(Miss F. M. L. Sheffield, D.SC.)	*Pathologist-in-Charge*
P. J. Dickinson, DIP. HORT.	*Scientific Assistant*
Peter Mwithiga	*Overseer*

ADMINISTRATION

ADMINISTRATION AND ACCOUNTS:

Lt.-Col. G. G. Robson, P.S.C.	*Administrative Secretary*
(H. B. Hobkirk)	*Accountant, posted from Accountant-General's Department*
Miss M. A. E. Vardy	*Personal Secretary to Director*
Mrs. M. M. May	*Personal Secretary*
Mrs. V. C. T. Knight, M.A.	*Personal Secretary*
Mrs. G. L. Dickinson	*Personal Secretary*
Mrs. W. Griffith	*Secretary/Stenographer*
Miss S. J. Newill	*Clerk*
(B. B. Purohit)	*Accounts Clerk, posted from Accountant-General's Department*
(K. Mudasia)	*Accounts Clerk, posted from Accountant-General's Department*
Matthew N. Waweru	*Administrative Clerk*
Edward Munyua	*Clerk*

MAINTENANCE, WORKSHOPS AND STORES:

J. B. Drummond, M.I.C.W.A.	*Maintenance Superintendent*
R. M. Angus	*Assistant Maintenance Superintendent*
L. R. F. D'Souza	*Storekeeper*
Vir Singh	*Foreman Artisan*
Sher Mohamed	*Foreman Artisan*
Noor Mohamed	*Foreman Artisan*
Soma Puna	*Senior Artisan*
Arthur Robert	*Artisan*
Ngarniya Waweru	*Artisan*
Geoffrey Mburu	*Stores Clerk*
John Ndungu	*Clerk*
Saduma Otiende	*Clerk*
Jackton Owake	*Overseer*
Kinyanjui Macharia	*Driver*
Baison Bwanansi	*Driver*

DEPARTURES DURING 1958

P. J. Greenway, O.B.E., D.SC., F.L.S.	*Botanist-in-Charge of the E.A. Herbarium, on leave pending retirement*
G. H. Gethin Jones, M.SC.	*Soil Surveyor-in-Charge, on leave pending retirement*
D. W. Gourlay, B.A. (AGRIC.)	*Field Experimentalist, on leave pending retirement*
J. Quarterman, PH.D., A.R.I.C.	*Biochemist, on resignation*
(L. R. Doughty, B.SC. (AGRIC.), N.D.A.)	*Geneticist (retired on the 1st January, 1959)*

PREFACE

The East African Agriculture and Forestry Research Organization (E.A.A.F.R.O.) is an interterritorial research organization administered by and forming part of the East Africa High Commission. It was set up in 1948 and absorbed the earlier East African Agricultural Research Institute at Amani, Tanganyika, which was started in 1927. E.A.A.F.R.O. is financed jointly by the three East African Territories of Kenya, Tanganyika and Uganda, by the Protectorate of Zanzibar, and by the United Kingdom Government through Colonial Development and Welfare Funds. Its headquarters and central laboratories, experimental farm and forest plantations are in Muguga Forest near Nairobi on the site generously given by the Government of Kenya.

E.A.A.F.R.O. works very closely with the corresponding organization for veterinary research, the East African Veterinary Research Organization (E.A.V.R.O.). The two organizations have a common headquarters at Muguga, and the two sets of laboratories and farms are on adjoining estates each excised from the Muguga Forest. They are jointly responsible for the Library, which is the largest and most complete library for agriculture and the agricultural and ancillary sciences in East Africa. In addition, research work on animal industry is shared out between them. It was originally carried out by the Joint Animal Industry Division under Dr. M. H. French, a Deputy Director, and it was a joint responsibility of the two Directors. With Dr. French's retirement in 1956 it was agreed that this joint Division be divided into two: an Animal Husbandry Division under the Director, E.A.A.F.R.O. and an Animal Production Division, dealing with animal breeding, physiology, and biochemistry under the Director, E.A.V.R.O. Muguga South Farm, which was used by the Joint Division, is still being used by the two Divisions, though it is now managed by the Director, E.A.A.F.R.O.

The general policy, both for E.A.A.F.R.O. and for E.A.V.R.O., is decided by the East African Agricultural and Fisheries Research Council, a Council whose members are nominated by the Territorial Governments, the High Commission and the Colonial Office, and this Council is also responsible for the general running of both the Organizations.

The principal functions of E.A.A.F.R.O. are to undertake research work that is either longer-termed than is easily undertaken

by the Territorial Departments of Agriculture and Forestry, or is common to all or several of the Territories, or which requires highly specialized equipment or research officers, which can only be justified in a central East African laboratory. Examples of each of these types of work will be found in the body of this Report. E.A.A.F.R.O., however, is only concerned with problems of local interest when specially invited by a Territorial Department. Its function is therefore to supplement and supply the background to the work of the territorial research workers.

The planning of the detailed research policy of E.A.A.F.R.O. must obviously be done in very close co-operation with the Territorial Departments, and this is ensured through three Research Co-ordinating Committees. These Committees, and others for other sciences, are under the Chairmanship of the Chief Administrative Secretary of the High Commission and the Director E.A.A.F.R.O. is a member of each. These Committees are for Agriculture, on which are the four Territorial Directors of Agriculture; for Animal Industry, on which are the Directors of Agriculture, the Directors of Veterinary Services and the Director E.A.V.R.O.; and for Forestry on which are the Chief Conservators of Forests. These Committees, in conjunction with the Research Council, keep under review all the research work in progress and decide on general priorities for research, particularly the longer-term or more specialized research that is the direct concern of E.A.A.F.R.O.

E.A.A.F.R.O. is also directly concerned with a further set of Committees, the Specialist Committees, which are composed of the actual specialist research workers in East Africa in each of the disciplines represented. These Committees are therefore competent to discuss the technical problems with which the research workers are faced in carrying out their work, and to make detailed proposals for new work or for an extension of current work.

It was decided at the 3rd Meeting of the Research Council held on 3rd February, 1955, that the Annual Reports of E.A.A.F.R.O. should be published in two parts; one part, which is contained in the Annual Report of the Research Council itself, is intended to tell the non-scientist of the work and achievements of E.A.A.F.R.O. in the year under review; the other part, which is this Report, is written more for the information of research workers, particularly in other parts of the world.

INTRODUCTION

CHANGES IN STAFF AND ORGANIZATION

1. *Staff Changes.* Four new Research Officers joined the staff during the year. Mr. H. Doggett to take charge of the Sorghum Breeding Research Scheme, Dr. W. J. A. Payne to take charge of the Animal Husbandry Division, Mr. O. Kerfoot who joined the staff of the Physics Division, and Mr. W. Wilkinson who joined the Forest Entomology Division, which has been closed since Mr. J. C. M. Gardner retired in April, 1957.

2. Four Research Officers have left during the year. Dr. J. Quarterman, a Biochemist, resigned to join the Rowett Research Station, Aberdeen, at the beginning of the year. Mr. G. H. Gethin Jones, in Charge of the Soil Survey Section, Dr. P. J. Greenway, in Charge of the East African Herbarium, and Mr. L. R. Doughty, in Charge of the Genetics Division, all retired after long service in East Africa. It is one of a Director's pleasant duties to record the very great contributions these three officers have made to agricultural and botanical research during the many years of service they have given in East Africa. In addition, Mr. D. W. Gourlay, who has been in charge of the Amani Sub-Station, has also retired, again after long service in East Africa.

3. *Reorganization of Divisions.* As a consequence of the retirement of Mr. Doughty it has been decided to close the Eldoret Sub-Station completely and to hand over all the maize varieties of value to the Department of Agriculture, Kenya, as it is hoped these will be of value to them in their maize breeding research programmes. As a further consequence of Mr. Doughty's and Mr. Gourlay's retirement it has also been decided to close the Amani Sub-Station completely in 1960, and only to use it for the bulking up of a few new varieties of cassava and as a store of plants of potentially useful varieties for the Territorial Botanists and Agricultural Officers to draw on till then.

4. Experience has shown that small sub-stations are not an efficient method for an interterritorial research station to carry out work which cannot be done at the central station, for it is very difficult for a research officer stationed there to play his full part in interterritorial research. The problem therefore arose of where the Sorghum Breeding Research Division under Mr. Doggett should be situated, as Muguga is an entirely unsuitable place for sorghum

research. It was with very great pleasure we were able to accept the kind invitation of the Minister of Natural Resources and the Director of Agriculture, Uganda, to put it at the Serere Agricultural Experiment Station—a station situated in a very suitable region of East Africa for sorghum work, and at which a number of research officers of the Department of Agriculture are also stationed. This placing of an E.A.A.F.R.O. Division at a Territorial Research Station should prove a much more satisfactory method of carrying out work we cannot do at Muguga, and I am hoping it will serve as an excellent example of the way that E.A.A.F.R.O. can make its fullest contribution to East African agriculture for certain lines of work. The Department of Agriculture, Uganda, is providing our staff with all the necessary laboratory accommodation and allowing them all the facilities for the field plots necessary, and the Colonial Office made a very generous grant of C.D. & W. funds for the necessary housing.

5. The Animal Husbandry Division has also been reorganized by Dr. W. J. A. Payne who arrived in February from Fiji to take charge of it. This Division will be divided into five sections, namely, Beef Cattle, Sheep and Goats, Pigs, Meat, and a Central Biochemical Section to serve these other four; and it is hoped that its general programme for the next five years will be agreed with all the Territorial Departments and with the Research Council early in 1959.

WORK ON OUTSIDE COMMITTEES

6. The Director is a member of the E.A. Agricultural, Animal Industry, Forestry, and Tsetse and Trypanosomiasis Research Co-ordinating Committees, and Chairman of the Soil Fertility and the Pasture Research Specialist Committees. He organized and was Chairman of Conferences on Agricultural Meteorology and on Agricultural Engineering both of which were held at Muguga in February, 1958. He is a member of the Kenya Agricultural and Veterinary Research Advisory Committee, the Kenya Pasture Research Committee, Chairman of the Research Committee of the Tanganyika Coffee Growers Association, a member of the Research Committee of the Tanganyika Sisal Growers Association, of the Governing Body of the Tea Research Institution of East Africa, and of the Namulonge Advisory Board of the Empire Cotton Growing Corporation. He is a member of the Scientific Council for Africa South of the Sahara (C.S.A.) and attended its 9th Meeting in Accra. He attended the 1st African

Weed Control Conference held in Northern Rhodesia in July, and with Dr. Pereira and Dr. McCulloch attended the Specialist Committee on Physical Hydrology organized by C.S.A. and held at Bukavu in the Belgian Congo. He was Chairman at the 1st Meeting of the East African Catchment Area Research Committee, which all the Research Officers and Scientific Assistants of the Physics Division attended, and was Chairman of the 3rd Formal Conference of British East and Central African Hydrologists which Dr. Pereira also attended as a member, both of which were held in Kampala in August. The Director also attended the Conference of Directors and Senior Officers of Overseas Departments of Agriculture and Agricultural Institutions held at Wye, and a Meeting of the Committee for Colonial Agricultural, Animal Health and Forestry Research in London in September.

7. Dr. H. H. Storey is a member of the E.A. Medical Research Council and the E.A. Industrial Research Board, a Trustee of the Coryndon Museum, Chairman of the Specialist Committee on Agricultural Botany and Chairman of the E.A. Standing Technical Committee on Plant Import and Export, of which Dr. F. M. L. Sheffield is also a member, and Mr. P. J. Dickinson of the E.A. Plant Quarantine Station is the Secretary. Dr. Storey was also Chairman of the Meeting of Experts called by the Inter-African Phyto-Sanitary Commission which met in Nairobi in April. He also attended the 7th International Microbiology Congress at Stockholm in August.

8. Dr. Pereira is the Secretary of the E.A. Catchment Area Research Committee, the Kenya Catchment Area Research Committee and the E.A. Regional Committee for the Conservation and Utilization of Soils. Dr. A. L. Griffith is a member of the E.A. Timber Advisory Board and Chairman of the Specialist Committee on Forestry. He attended the 2nd Inter-African Forestry Conference held at Pointe Noire in July organized by the Commission for Technical Co-operation in Africa South of the Sahara (C.C.T.A.). Dr. Payne is a member of the Kenya Pasture Research Committee. Mr. J. Glover is a member of the Kenya Pyrethrum Technical Consultative Committee, and Dr. H. F. Birch is a member of the Kenya Wheat Baking Quality Committee. Mr. H. P. Ledger attended by invitation meetings of the Kenya Pig Industry Board.

WATER AND CROP GROWTH

THE WATER USE OF TREES AND CROPS AND THE EFFECTS OF LAND-USE ON STREAMFLOW AND LOCAL CLIMATE

CATCHMENT AREA RESEARCH

H. C. Pereira, J. S. G. McCulloch, M. Dagg, O. Kerfoot, P. H. Hosegood, J. W. Simmons, assisted by E. Kasavuli, S. Ngethe, A. W. Charles, J. Mudianga and J. K. Njoroge

9. Most of the numerous procedural and financial complications of these inter-departmental research projects have been solved during the past two years, and none of the difficulties have been allowed to interrupt the field progress of the four main investigations.

10. On the Mbeya Range the soil washed from the steep hillside cereal crops of the Wasafwa cultivators caused some difficulty with streamflow measurements early in the year, but the Tanganyika Water Development Department has constructed an effective concrete silt-trap for protection of the measuring weir. This will permit measurement of the bedload of the stream. Daily sampling of the sediment-load is in progress and methods of flood sampling are being studied. The rainfall for the 1957/58 season has averaged 54 inches in the lowest, and 61 inches on the highest valley. Statistical analysis has shown no significant differences between the daily catches of the five ordinary and two autographic gauges within each catchment, and in spite of the steep and broken topography a mean value for each valley has proved the best estimate.

11. In the tall rain forest at Kericho, Mr. Simmons has completed the difficult task of detailed topographic survey along narrow paths cut through the undergrowth without disturbing the dense forest canopy of the 1,700-acre Sambret valley which is to be converted into tea plantations. 1,100 acres have proved suitable for conversion to tea-gardens while much of the remaining area will be converted to fuel plantations. The weirs built by the Hydraulic Engineer's Branch of Kenya's Ministry of Works for autographic streamflow measurements have functioned well. While Messrs. Brooke Bonds have constructed a main access road, with perimeter and survey traces on the Sambret valley, the Forest

Department has cleared perimeter traces and survey-paths in the Lagan valley which will serve as the forested control area. Rainfall measurements in the high forest canopy, from platforms in the tops of 100-foot high trees, have been compared with those made in special clearings. Soil moisture recordings both by electrical resistance methods and by direct sampling to 10-feet depth have given a complete year's records of the changes under high forest. The Soil Conservation engineers of the Kenya Department of Agriculture have undertaken the design of cut-off drains and measuring flumes to collect and meter the surface run-off both from the administrative area of the tea estate, which will contain the tea factory, labour lines, offices, garage, etc., and also from a representative 30-acre area of tea-gardens.

12. In the Aberdare Mountains north of Nairobi the study of the conversion of bamboo forest to softwood plantations has been substantially increased in scale during the year under review. In the same area of mountain forest there is wide overlapping of the large-scale planting of pines with the large-scale collection and off-take of water supplies for the city. This renders the separate evaluation of the two effects essential as a basis for development policy in these areas having major natural resources of water and timber. From the three well-equipped valleys, of 40, 90 and 160 acres respectively, already under intensive study, the experiments have this year been extended to two further catchments each of over 2,000 acres in area. Dry weather flows of successive stages of the whole 25,000 acres of the Thika-Kimakia system lying within the Forest Reserve are now being recorded. Many gloomy opinions of the water-use of Kenya's forests have been based on river-gauging at lower altitudes, together with estimates of rainfall over the forests which were little more than guesswork. With a close network of both daily read and autographic raingauges, and with streamgauges sited within the forest itself, very different results are emerging; valleys under dense bamboo are yielding over 50 per cent of the rainfall as streamflow, and this rises to 70 per cent where bamboo has been replaced by newly planted pine trees, intercropped with vegetables.

13. Only in the rather primitive Karamoja District of Uganda has the catchment-area research run into unexpected difficulties, and these are of a social rather than a technical nature. Where cattle raiding is still a popular tribal diversion which occupies the police force to the full, it is perhaps not surprising that protection of scientific equipment is difficult. Technical difficulties have arisen

in the design and construction of the massive flumes which measure the torrential streamflows from this overgrazed thornbush country, but such difficulties are being met by existing engineering skills and by determined experimentation. This study of the extent to which pasture improvement and grazing management can modify the destructive torrents which at present rule this overgrazed countryside is basic to our understanding of much of East Africa's drier pastoral areas. The several Uganda Natural Resources Departments who are co-operating with this Organization in helping the Karamoja Development Committee will need very staunch administrative backing to ensure success of this important project.

14. Since all four experiments involve study of the hydrological effects of a change in the vegetation of a catchment area, Mr. Kerfoot has begun a detailed botanical collection on each. Dr. Verdcourt, Miss Napper and Mrs. Church of the East African Herbarium have identified the 700 species so far collected.

15. Detailed ecological and botanical surveys of the four major catchment areas of East Africa were initiated in April.

16. *Mbeya.* Nearly 200 species were collected from Catchments B and C and identified, several being new records for the territory and one or two new to East Africa.

17. Catchment C consists largely of high forest remnants with secondary woody species vigorously colonizing gaps left after fire and exploitation. Catchment B is a heavily cut-over and cultivated patch of forest and is now covered largely by ruderal growth which may respond to protection and artificial treatment by gradual development of a woody vegetative cover. Catchment A is in a late transitional stage of retrogression from secondary grassland and relatively stable high forest to cultivated land. This Catchment has not yet been surveyed in detail.

18. *Kericho.* Only one of the catchments has been studied in any detail but vegetation problems are fairly simple. With certain qualitative and, possibly, micro-climatic differences, the three catchments are hydrologically comparable. The stable vegetative pattern is essentially high montane evergreen forest with bamboo. Approximately 100 species have been collected and identified from Sambret Catchment.

19. *Kimakia.* Qualitative vegetation surveys of the four major catchments have been completed and over 200 species collected and identified. There is complete natural vegetative cover comprising bamboo with mixed evergreen forest species (including *Podocarpus milanjianus, Ekebergia rueppeliana, Lachnopylis congesta*) and a rich herbaceous flora of hydrological significance.

20. *Karamoja.* The vegetation reflects the misuse of land by overgrazing and the overriding significance of precipitation. Nearly 200 species have been collected including several new records. The characteristic physiognomy and structure of the vegetation are those of a semi-arid flora in spite of a rainfall of over 30 inches. The overall effects of overgrazing followed by erosion are to increase the run-off, reduce the rainfall acceptance of the soil (which in turn has in places been stripped to a rock mantle) and impoverish the vegetation. Maximum benefit is afforded to woody and xerophytic thorny species with strongly developed root systems and well-protected seeds of long viability. There is a dearth of herbaceous genera (except in certain favoured localities) and the open, and generally mono-storied, structure of the woody cover is unfavourable to the development of useful grasses. The trend will, of course, be reversed when the bush is cleared and controlled rotation grazing is begun. Detailed root studies will follow.

21. The first meeting of the East African Standing Committee on Catchment Area Research was held in Kampala in June, in conjunction with the Third Formal Hydrology Conference of East and Central African Territories. Progress reports on the four main projects were issued and discussed. It was agreed that E.A.A.F.R.O. would in future prepare brief half-yearly progress reports for the Catchment Area Research Committee of each territory.

AGRICULTURAL METEOROLOGY

J. S. G. McCulloch and S. Ngethe

2. Two main objectives have been pursued this year. The first has been the application to East African conditions of Penman's method of estimation of evaporation from other meteorological data while the second has been the study of the estimation of total rainfall over restricted areas with fairly close

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA, 1958

	RAINFALL	AIR TEMPERATURE			AIR HUMIDITY			WIND SPEED	RADIATION	SUN-SHINE	OPEN WATER EVAPORATION			
		MONTHLY MEANS OF DAILY VALUES									MONTHLY TOTALS			
	Monthly Totals	Max.	Min.	Mean	Dew Point Mean of 0830–1600	Saturation Mean of 0830 and 1600 hrs.	R.H. at 1600 hrs.	Mean Wind Speed at 6 ft. above ground	Kipp-Moll Solarimeter	Mean Daily Sunshine Hours	Sunken Pan Air-Insulated from Soil	Australian Pattern 3 ft. Deep Sunken Tank	Raised Pan with Heavy Grid Cover	Class "A" Pan
	Inches	°F	°F	°F	°F	mm. of Mercury	%	M.P.H.	Inches* Water Evaporated	Hours	Inches	Inches	Inches	Inches
Jan.	0·90	72·7	53·8	63·3	52·3	4·75	51	10·6	11·55	9·2	7·16	6·43	8·28	9·26
Feb.	5·46	73·7	53·9	63·8	51·5	5·22	51	7·4	10·37	8·8	5·93	5·77	7·08	7·90
Mar.	3·41	73·5	54·7	64·1	54·2	4·52	53	8·4	10·98	8·8	6·85	6·27	7·61	8·33
April	4·79	71·6	55·1	63·4	55·3	3·69	60	8·8	9·78	8·0	5·64	5·36	6·17	6·75
May	11·82	67·7	54·0	60·9	56·5	1·94	77	6·1	7·80	5·4	4·13	3·91	3·88	4·87
June	2·89	65·1	50·8	58·0	53·8	1·72	74	4·4	6·82	4·6	3·28	3·09	3·22	3·75
July	2·41	62·6	49·1	55·8	52·7	1·20	76	4·2	5·49	2·9	2·41	2·28	2·46	2·86
Aug.	0·28	65·5	48·5	57·0	51·0	2·33	64	6·0	7·65	5·6	3·74	3·52	4·14	4·58
Sept.	0·08	71·2	49·2	60·2	50·2	3·96	48	7·0	9·81	8·4	5·43	5·26	6·06	6·60
Oct.	2·33	71·8	52·2	62·0	50·5	4·78	47	8·1	10·32	8·0	6·32	6·01	6·80	7·72
Nov.	2·39	71·7	52·3	62·5	52·7	4·20	52	10·4	10·93	9·0	6·21	6·28	7·13	7·62
Dec.	2·54	69·7	53·5	61·6	54·5	3·13	65	9·5	9·82	7·0	5·32	5·29	5·88	6·39
Annual Totals	39·30	—	—	—	—	—	—	—	111·32	—	62·42	59·47	68·71	76·83
Annual Means		69·7	52·3	61·0	52·9	3·44	60	7·6	—	7·1	—	—	—	—

*1 inch water evaporated = 1498·6 gm.cals/sq. cm.

distributions of rainguages. Both of these studies have been conducted as an integral part of the catchment area experiments outlined above: these experiments cover a wide range of East African environments, and have full-time teams of resident African observers supervised by the nearest Forest Officer. The dominant importance of the radiation term, already noted for local conditions in earlier E.A.A.F.R.O. work (Annual Report, 1955), was found to hold true over this far wider range of conditions. It is characteristic of East Africa that windspeeds are lower than those of the U.K. in which the method was evolved, while the air is rarely wet enough to limit evaporation. New tables, using radiation constants deduced from East African observations, were drawn up for rapid computation of the evaporation estimate. These are under discussion with Dr. Penman and it is hoped to publish them shortly.

23. The use of tree-top platforms for rain-gauging at the level of the forest canopy was rendered considerably more convenient by the use of $\frac{1}{4}$-inch diameter tubing of polyvinyl chloride, by which the catches of standard 5-inch diameter funnels on the high platforms were transferred to large bottles at ground level. The P.V.C. tubing is not wetted and transmits the water from funnel to reservoir without loss. On each of nine tree-top platforms both a standard Snowdon gauge and a gauge equipped with plastic down-pipe and storage reservoir were read daily for 200 days, the observers climbing ladders nailed to the tree-trunks. The mean daily differences averaged 0.003 inches, the catch of the standard gauges being slightly less than that of the piped gauges.

24. Some exploratory measurements were also undertaken to find the optimum size of forest clearing in which to expose a raingauge a little above ground level. In discussions at the U.S. Weather Bureau in 1957, Dr. Pereira had received advice that clearings could be substantially smaller than those needed to limit screening to the usual angle of 30°. Felling tall rain forest and disposing of the bulky material is a major task in catchment experiments, while causing serious local alterations in the environment under study. Tree-top platforms afford one practical solution to this problem, but in 100-foot high rain forest, as at Kericho, they are slightly hazardous undertakings. Small clearings may offer a useful alternative. Four clearings were made in 35-foot high bamboo, to give screening angles of 30° to 75°. Observations over 42 rainy days in a three-month period gave the following results.

Average screening angle	75°	60°	45°	30°
Rain catch as % of that in the open	87%	92%	98%	100%

Thus the much smaller 45° clearing gives results approximating closely to those in the open.

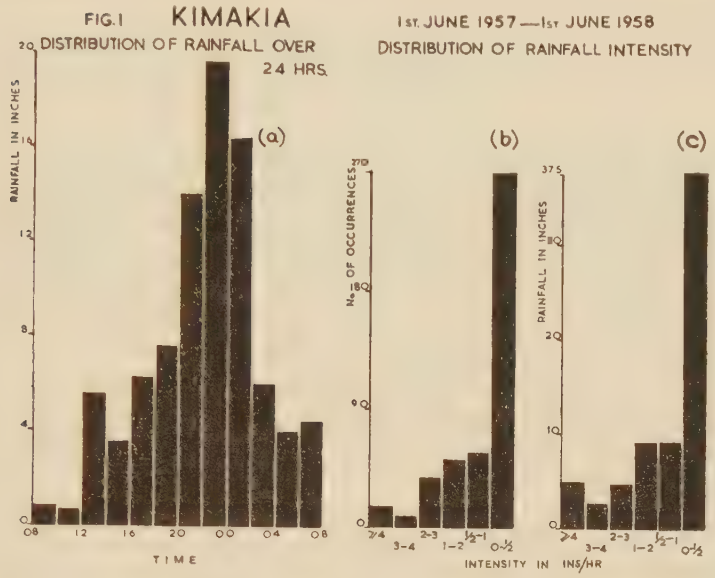
ANALYSIS OF STORM RAINFALL

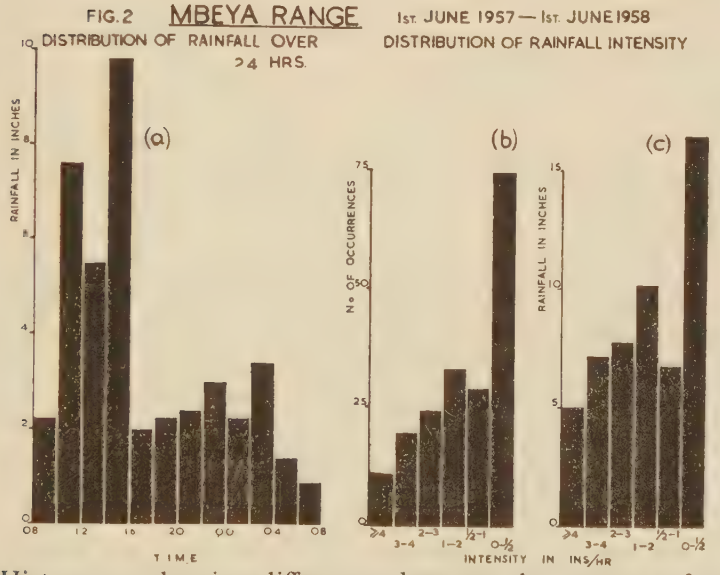
M. Dagg and A. W. Charles

25. In catchment area research and soil erosion studies it is important to be able to describe the storm characteristics of the rainfall. The principal features are the quantity, time of day, duration and intensity of the rainfall. In remote areas with semi-skilled observers, the only reliable instrument which can be used for storm assessment is an autographic rain-gauge which indicates the cumulative total of rainfall against the time of day. The intensity is given by the slope of the trace, and the other parameters can be measured directly from the chart.

26. A breakdown of the rainfall record into 10-minute periods is adequate for the relation of run-off to rainfall. Using a template scribed at 10-minute intervals, and another with standard slopes, the quantity of rain falling in each 10-minute period is recorded on the chart together with the maximum intensity of rain during each period. From these data, histograms can be prepared showing the quantity of rain falling at different times of the day, the frequency of occurrence of different intensities and an approximation to the quantity of rain falling at different intensities.

27. The results of such analyses for one year's rainfall on the catchment areas at Kimakia and Mbeya are shown in Figs. 1 and 2. The differences in the pattern of rainfall at the two places are clearly revealed. The rain at Kimakia falls mainly late in the day with a peak near midnight, whereas at Mbeya the maximum rainfall occurs near noon and a much greater proportion of it falls at high intensities. Similar analyses for the rainfall at Muguga and the Kericho catchment area show that the pattern at Muguga is rather like that at Kimakia, but at Kericho there is a marked rainfall peak at 1600 hours and a large proportion of the rain falls at high intensities.





Histograms showing differences between the patterns of storm rainfall: (Fig. 1) at Kimakia, in the Aberdare Mountains, Kenya, and (Fig. 2) at Mbeya Range, S. Tanganyika.

(*a*) Average diurnal distribution of rainfall.

(*b*) Distribution of occurrence of rainfall of different intensities (based on hourly intervals).

(*c*) Quantity of rain falling at different intensities (based on 10-minute intervals).

IRRIGATION STUDIES

H. C. Pereira, J. S. G. McCulloch, M. Dagg and P. H. Hosegood

28. In continuation of previous work on estimation of the irrigation requirements of Arabica Coffee, soil sampling at Ruiru again gave agreement between the calculated and measured water use of the crop, within the standard error of the sampling. The main limitation in the use of these results is that few coffee planters are yet equipped to measure, with any useful accuracy, how much water they are in fact applying. Dr. Pereira and Mr. R. W. Rayner of the Kenya Coffee Research Station paid a three-day visit to the Tanganyika Coffee Research Station at Lyamungu to study the 15-year record of their irrigation trial and to advise on future irrigation studies.

29. Both standard production models and prototype design models of the Gunn-Bellani radiation integrator were received from Messrs. Baird & Tatlock for testing. Breakages in transport caused some initial difficulties, but fully effective methods of packing for shipment have now been achieved. A paper by Dr. Pereira on the estimation of evaporation from radiation measurements and from these simple distillation instruments was accepted for publication in the Quarterly Journal of the Royal Meteorological Society.

30. Equipment for accurate determination of crop water use data was obtained during the year by the Perkerra Irrigation Scheme in Kenya and the Mbarali Irrigation Scheme in Tanganyika, but staff shortages prevented the collection of the essential data. Arrangements were therefore made to equip the Physics Division with a mobile caravan so that E.A.A.F.R.O. staff could reside on each scheme in turn for long enough to install equipment and to take sets of measurements.

31. Data from eight evapotranspiration tanks, operated at Muguga for the past three years and incorporating gypsum blocks and tensiometers, have shown that the Garnier type, in which water is poured in daily from the top, give results substantially different from those of tanks in which a water-table is maintained at a depth of two feet below the surface. Under African conditions buried tanks must be easy to lift for inspection, and balance tanks were therefore connected by siphons. Glass inspection tubes with taps for drawing off entrapped air were found necessary. All eight

tanks, four of which are under permanent grass while four are following a crop rotation, have now been fitted with 4-inch tube wells with floats bearing water-level indicators.

32. Comparisons of annual totals are given in the following table for permanent grass, kept at about the same length as that of a continuously grazed 20-acre paddock to windward. The tanks stood in one-tenth of an acre plot of the same grass (*Cynodon dactylon*).

	1956/57	1957/58
Watered from surface	45.5 inches	50.3 inches
Watered from balance tanks ...	—	72.3 inches
Trumble tank	60.3 inches	59.9 inches
Class "A" pan	—	73.4 inches
Muguga-pattern sunken air-insulated tank	63.3 inches	64.2 inches
Penman's estimate	68.3 inches	69.8 inches

33. Records of electrical resistance units and of porous pot tensiometers in the surface-watered tanks showed that soil moisture deficits sometimes occurred in spite of the presence of drainage; possibly the latter followed root channels or insect burrows.

34. The $2\frac{1}{2}$-inch difference in 1957/58 between the water use of grass in the balance-tank equipment and Penman estimate for open water is probably due to the "island effect" since it is difficult to prevent grass when fully supplied with water from exceeding the height of the grass surrounding it and from time to time the grass in the tanks was found to be projecting above its surroundings. The extra surface for reception of radiation together with extra ventilation can then account for a considerable increase in water use. In general this study illustrates what arbitrary and difficult instruments evapotranspiration tanks can be. Their results must always be regarded with great caution. The deep soils of East Africa provide ample reservoirs in which moisture changes can be measured on a field scale, and provided that tension changes are also followed, the field studies avoid the acute limitations of the small lysimeters.

SOIL PHYSICS

M. Dagg, P. H. Hosegood and A. W. Charles

Structural Effects of Cattle Trampling

35. At the Serere Experiment Station of the Department of Agriculture, Uganda, a positive response to a dressing of farmyard manure has been found for most crops. Night paddocking of cattle on ley plots should therefore result in beneficial manurial effects on subsequent crops of cotton. However, the trampling of the ground by cattle may have detrimental effects on the soil structure which would counteract the benefit due to the manure. A short-term experiment was designed therefore to compare the yield of a cotton crop following an untouched ley with that following a ley which had been used as a night paddock for cattle. Two levels of stocking were used, one giving a total of 600 beast nights and the other 1,500 beast nights per half-acre plot in 300 days. E.A.A.F.R.O. Physics Division was invited to investigate the changes in soil structure under these different treatments.

36. Undisturbed soil core samples were taken from each of the treatments in March, 1958, immediately prior to ploughing and then again in July when the cotton crop was established. It was found that, before ploughing, the acceptance of heavy rainfall by the cores from the grazed plots was significantly less than by those from ungrazed plots. The different stocking rates did not produce any significant differences, but there was a suggestion that the heavier stocking rate was causing more structural deterioration than the other. However, measurements made on cores after breaking showed that the ploughing had eliminated all of the physical differences previously measured.

37. The most striking feature of the results was a drop of more than 50 per cent in the rainfall acceptance as a result of ploughing in spite of an increase of more than 100 per cent in the volume of large pore spaces in the first three inches of soil. The unstable nature of this soil, when unprotected by grass, leads to immediate capping under heavy rain. The data are illustrated in Table I.

Pressure Membrane Equipment

38. Six units of a pressure membrane equipment have been assembled and are in process of final refinement. They will be

used to obtain the moisture characteristics of soils and for the routine determination of the wilting point of soils in connexion with studies of soil water storage.

TABLE I

SERERE NIGHT PADDOCKING TRIAL—PHYSICAL CHANGES IN THE TOPSOIL

	Ungrazed		Lightly Stocked		Heavily Stocked	
	Before Ploughing	After Ploughing	Before Ploughing	After Ploughing	Before Ploughing	After Ploughing
Rainfall Acceptance of 6"/hr. storm. (in inches/hr.) ..	4·07 ±0·24	1·41 ±0·12	3·27 ±0·28	1·67 ±0·19	2·96 ±0·23	1·31 ±0·10
Total Pore Space .. (%Total Volume) ..	45·25 ±0·57	50·17 ±0·55	44·93 ±0·55	50·63 ±0·87	44·26 ±0·47	49·30 ±0·93
Pore space drained at tension of 20 cm. of water. (% Total Volume)	8·67 ±0·81	18·24 ±0·94	7·50 ±0·86	16·94 ±1·43	6·83 ±0·65	17·21 ±1·49

STUDY OF SHADE TREE EFFECTS IN TEA PLANTATIONS

H. C. Pereira, O. Kerfoot, J. S. G. McCulloch, M. T. Friend and P. H. Hosegood

in collaboration with Mr. N. Goodchild of the Tea Research Institute of East Africa

39. Many textbooks on the tea plantation industry quote detailed supposed advantages conferred by shade trees, but only very slight and fragmentary scientific evidence exists for these effects. Since many thousands of pounds have already been spent in establishing and maintaining shade trees in East African tea plantations, and the field practices vary in a most contradictory fashion, this difficult problem of physics, physiology and agronomy has been undertaken jointly by E.A.A.F.R.O. Physics Division and the Tea Research Institute, with the co-operation of Messrs. Brooke Bond East Africa Limited. An exploratory experiment laid down in mature tea under two contrasting systems of pruning of *Grevillea robusta* on the Mabroukie Estate at Limuru is already giving promising results. Yield measurement from 76 plots, 2

bushes wide by 50 long, are being compared with the degree of shading, measured primarily by direct hour-by-hour counts of the number of bushes shaded; these counts are supported by periodic measurement of the intensity of solar radiation at the crop surface, using a newly calibrated Kipp and Zonen thermopile and portable galvanometer. Simultaneous measurements of light intensity by selenium cell lightmeters with diffusion screens, by exposure of horizontal glass tubes containing standard solutions of anthracene in benzene and by Gunn-Bellani radiation integrators, are in progress in search of a field method of radiation assessment which can use equipment less expensive and delicate than the Kipp solarimeter. The chemical method is sensitive to a wavelength of 350mμ ~~650 μ~~, the lightmeters respond to the visible waveband, while both the thermopile and the distillation instruments have black reception surfaces limited to short-wave radiation by their glass envelopes. After finding how the crop yield is affected by the presence and duration of visible shade, it is then necessary to study the wavelength of the radiation to which the tea is most sensitive. Effects on soil moisture and micro-climate are also being explored.

40. Results from 36 soil moisture profiles to 15 feet depth have shown larger soil moisture deficits, and suggestions of greater water use, by tea bushes hedge-planted at 5 feet × 2 feet (4,800 bushes per acre) than by the usual spacing of 4 feet × 4 feet (2,700 bushes per acre). Tea under large *Grevillea robusta* shade trees had less soil moisture than unshaded tea, but the differences were smaller than those due to the spacing of the tea. The extra foliage area exposed to sunlight on the sides of the hedge-planted bushes accounts for the extra transpiration.

LAND-USE PROBLEMS OF CLIMATE AND WATER RESOURCES

41. At the invitation of Ministries of all three Territories, Dr. Pereira took part, with technical officers of the various Natural Resources Departments, in reconnaissances on the following problems:—

(1) The effects of game animals and of cattle on the water sources of the Matthews Range in northern Kenya.

(2) The probable hydrological effects of establishing Tea Plantations in the Nou Forest, in Tanganyika's Northern Province.

(3) The effects of land misuse in the Perkerra catchment on the dry-weather flow available for the Perkerra Irrigation Scheme in the Rift Valley Province of Kenya.

(4) Problems of the tea, coffee and pyrethrum crops in the Southern Highlands Province of Tanganyika.

Reports were prepared on each of the above subjects.

42. On the invitation of the C.S.A., Dr. Pereira joined the Specialist Committee on Physical Hydrology at Bukavu. Dr. McCulloch also attended as an Observer. Six officers of the Physics Division, after taking part in the meeting at Kampala on East African Catchment Area Research, attended the first day of the Third Formal Hydrology Conference of East and Central African Territories, at which Dr. Pereira read a paper on catchment area research methods.

43. In June, the Physics Division had the pleasure of a three-week visit by Dr. H. L. Penman, the Head of the Physics Department at Rothamsted. Visits were paid to the catchment area experiments in Kenya and Uganda, to the Perkerra Irrigation Scheme and the irrigation experiments at the Coffee Research Station at Ruiru as well as to the Serere Experiment Station. After Dr. Penman had spent a subsequent three weeks at the Namulonge Cotton Research Station, the four Research Officers of the Physics Division visited the Cotton Research Station and took part in a round table discussion on the estimation of crop-water use.

PLANT PHYSIOLOGY

J. Glover

44. The Plant Physiologist was on home leave from February until September and as no assistant was available the work of this Section ceased during his absence. He is indebted to Miss J. Kenworthy and Dr. J. S. G. McCulloch for the supervision of the final few weeks of a field trial with sorghum which was delayed by unseasonal rain. Miss Kenworthy, a Leverhulme Fellowship Research Student, continued her work in this Section until the middle of the year. She returned to Oxford in June.

45. The greater ability of sorghum stomata to recover from severe drought, as compared with those of maize, was confirmed in the field. Thus some of the well-known resistance to drought

by this crop is probably due to the ability of its stomata to recover from severe water shortage.

46. Studies of the apparent behaviour of stomata during and after recovery from drought are being extended to other important crop plants. The first to be investigated will be the groundnut.

47. In the joint experiment with Dr. Dougall of the Grassland Research Station in Kitale, recordings of weekly changes in the chemical composition of grasses continued under his supervision. These now indicate the importance of sulphur, at least in Star grass, in this area. Both the nitrogen/sulphur and phosphorus/sulphur interactions may be readily traced, and indeed in the actively growing plant the interaction of all three is predominant. This interaction has not so far been found in the mature material after heading and flowering when, except for carbohydrate increase, much activity ceases. So far the analyses have only been concerned with total sulphur irrespective of its nature, whether bound in the organic material or as free sulphate.

48. Preliminary results, which only took into account the average status of N, P and S during growth, indicated that there might be a marginal supply of sulphur from the soil in this area. Since this was of potential importance it was investigated in greater detail. The source of the apparent deficiency was found in the group of records which dealt with early growth at the end of the dry season and the beginning of the rains. They were of such an extent that they depressed the average S/N ratio to a value which could be associated with sulphur deficiency. The latter stages of the first crop and all the stages of regrowth of the second crop during the rains and in the period tailing off into the dry season did not show this effect.

The effect of altitude on the temperature and dew point of the air

49. Miss Kenworthy has continued her study of the altitude dependence of dew point temperatures and vapour pressure in East Africa. She has shown that apart from the predominant altitude effect there is also a slight dependence on longitude. It represents a difference of only 2.2° F. between the extreme western and eastern stations, nevertheless it must be taken into account.

If the mean effect of longitude is used, the simple general expression

$$T \text{ dew } (°F.) = 72.4 - 0.00937 \text{ h (metres)}$$

describes the results from the East African data. This equation is very similar to that of Hann, whose expression

$$e = e_o 10^{-h/6300}$$

gives a regression coefficient of 0.00936 when it is expressed in the form of dew-point temperatures.

50. Hann's equation has found fairly general acceptance and the East African measurements suggest that it is suitable for this region. On the other hand Tunnell's more recent equations do not fit the East African data, and both the East African and Hann equations differ significantly from them. It is therefore suggested that there is no need to discard Hann's expression in favour of those by Tunnell, at least so far as East Africa is concerned.

SOIL FERTILITY STUDIES

HUMUS DECOMPOSITION AND SOIL NITROGEN

H. F. Birch and C. C. Hood

51. The effect of soil drying on humus decomposition and the mineralization of soil nitrogen has been further studied with regard (*a*) to the mechanism involved and (*b*) to the influence of the length of the drying period on various soils.

52. In studying the mechanism involved it was found that the addition of activated charcoal to a dry soil (5 g. per 100 g.) completely inhibited the flush of decomposition that normally occurs when a dry soil is moistened. Charcoal was also found to adsorb soluble organic material from aqueous soil extracts, and it is evident that this material plays a part in the flush of decomposition that follows the moistening of a dry soil. This experiment supports the hypothesis, mentioned in the 1957 Annual Report, that drying a soil increases the amount of decomposable organic material subsequently going into solution. This has now been further confirmed by extracting both air-dried and oven-dried soils with water. In each instance the subsequent magnitude of decomposition of the moist extracted soils was less than that of the control, i.e. the non-extracted soil brought to the same moisture content. The magnitude of decomposition for the control was, in turn, less than that for the soil moistened with the soil extract. Concentrated aqueous extracts of air-dry and oven-dry soils were also found to decompose when mixed with sand.

53. In further studying the effect of drying and heating on the amount of decomposable organic material that subsequently goes into solution the following observations were made:—

(*a*) The longer a soil is air-dried or oven-dried (up to 12 days at 100° C. in the latter instance) the greater the amount of organic material that can be extracted and the greater the magnitude of decomposition on wetting.

(*b*) Whether a moist soil is oven-dried direct, or first air-dried or dried in a vacuum over phosphoric oxide and then put in the oven, the subsequent magnitudes of decomposition and the amounts of material extracted are the same. These observations, particularly (*b*) indicate that on oven-drying soils heat does not cause the movement of soluble organic

material (while the soil is still moist) from within cellular material to the outside (whence it can be extracted) since such movement could not occur with a soil that has been dried to virtually an oven-dry degree over phosphoric oxide. It appears more probable that on air-drying a soil slow progressive changes take place in the organic colloids and that these changes are greatly accelerated by heating. The changes visualized though not yet proven are considered to involve dehydration causing shrinkage and cracking of the micro-crumbs, possibly bound together to some extent by the humus fraction, with the splitting of these crumbs into smaller units with consequently increased exposure of a larger surface to the solvent action of the added water.

54. There is evidence that this increased solution of material is not, however, the only factor responsible for the flush of decomposition that follows the moistening of a dry soil. Both drying and heating cause microbial death and, on rewetting, a fresh, highly active microbial population develops, its activity falling off as the population ages and conditions become increasingly adverse to microbial activity, e.g. crowding of the viable population in the restricted space available to them. As evidence for this when a moist slowly decomposing soil was treated in a vacuum with chloroform, ether or formaldehyde vapours, followed by their removal, a flush of decomposition immediately occurred and when this was over the moist soil had merely to be treated again with the vapour for another flush of decomposition to occur, and so on with successive treatments.

55. These treatments were found not to involve any increased solution of organic material nor was the flush of decomposition influenced by the presence of activated charcoal, a further indication that soluble material is not involved. Since the soils were constantly moist the treatment effect must be ascribed largely to microbial death followed, once the adverse conditions are recovered, by a burst of microbial activity as a fresh population develops. It is significant that actinomycetes (kindly identified by Dr. Millbank) were found in the more vigorously treated soils (3 to 6 hours in contact with vapour) since it has been reported in the literature that acid-soluble soil organic material rather than water soluble material forms a more suitable food for actinomyces than for bacteria and fungi. Successive treatments with vapour appear then to involve successive cycles of microbial activity at the

surface of the organic material. While, then, the flush of decomposition that follows the moistening of a dry soil involves the utilization of soluble substrate it is possible that enhanced microbial activity associated with a newly developing population is also involved.

56. Soil drying is important in soil fertility, because the enhanced decomposition (over non-dried soils) that occurs on moistening is invariably accompanied by enhanced production of ammonia and nitrate (*see* later), particularly during the first 2–3 days of decomposition. At present it is not clear whether decomposition of the soluble material is involved in this enhanced nitrification or whether it is a consequence of increased surface exposure of organic material, decomposition and nitrification then being purely surface processes. The soluble organic material extracted from air-dry or oven-dry soils when added to either sand or soil appears, from the limited number of experiments so far carried out, to decompose without concommittant nitrogen mineralization. If this is further confirmed it would appear that nitrification is, in fact, a surface process and that drying a soil leads to enhanced exposure of organic surfaces, as mentioned earlier, with consequently enhanced decomposition and nitrogen mineralization on moistening. The high enzyme activity of the developing microbial population will also be involved. Later, as the colloids swell and cohere the area of exposed surface will decrease and this, together with the fall off in microbial activity, will lead to the decrease in the rate of decomposition and nitrification that invariably occurs.

57. With regard to the influence of the length of the drying period on various soils results of considerable interest have been obtained. The magnitudes of decomposition and nitrogen mineralization depend on the carbon (organic matter) and nitrogen contents of the soil and the length of the drying period. Soils ranging from 1 per cent to 7 per cent carbon are being studied over air-drying periods of 3, 6, 9, 12 and 15 weeks. After these periods the soils are brought to field capacity and the magnitudes of decomposition and nitrogen mineralization (for a period of 19 days after moistening the soil) are compared with those for a control soil (no drying) over the same period. The results to date, expressed as parts of mineral nitrogen per million of soil (on a dry basis) are tabulated below:—

	Weeks dried prior to moistening & incubation of soil			
% C in soil	Control	3	6	9
7	274(2,740)	406(4,060)	477(4,770)	509(5,090)
6	221(2,221)	298(2,930)		
5	185(1,850)	245(2,450)		

58. The figures in brackets express these amounts of nitrogen as ammonium sulphate equivalents per acre 6 inches of soil (2 million pounds). With the 7 per cent C soil air-drying for 3, 6 and 9 weeks has produced extra nitrogen after moistening and decomposition equivalent to 1,320, 2,030 and 2,350 lb. of sulphate of ammonia per acre, effects of considerable magnitude. For the 6 per cent and 5 per cent C soils the figures are 759 lb. and 600 lb. respectively for 3 weeks drying. Carbon mineralization showed similar trends but of greater magnitude. The importance of soil drying from the soil fertility point of view cannot be doubted. When the experiment is complete the data should form a useful guide in work involving nitrogen fertilizer trials, irrigation, etc.

59. These investigations reveal an interesting and important aspect of soil fertility, namely soil drying, the effect of which probably includes factors other than enhanced nitrogen mineralization. Brifly, a soil is more productive during the early part of the wet season than later on. This has been confirmed by various observations and reports. Data kindly supplied by Dr. A. C. Evans, Chief Research Officer of the Tanganyika Department of Agriculture showed a very rapid decline in yield of various crops as these were planted progressively later after the start of the rains. A similar effect has been reported (private communication) with crops planted at different periods after irrigating a soil. This infers that it would be a good practice, if possible, to let a soil dry out prior to irrigating rather than to start irrigating immediately after the rains cease. While the enhanced mineralization of nitrogen that follows the moistening of a dry soil must be partly responsible for these results other factors are also probably involved. Enhanced mineralization of phosphorus may occur, and the physical state of the soil soon after the rains must be better than later on when the soil colloids have swollen, leading to reduced aeration. It has also been found here that the amount of manganese that can be extracted from a dry soil was considerably greater than from a moist soil and the same may apply to other trace elements. By planting soon after the rains begin advantage is taken not only of the relatively high rate of mineralization that then occurs, but also of the greater amounts of extractable material that go into solution under these conditions. Better physical conditions, at least during the early period of plant growth, are also assured.

60. *Field Trials.* Humus decomposition and nitrogen mineralization under bare fallow grass and legumes is being studied. Changes in the total nitrogen and carbon contents of the

soil are too small for marked treatment effects to show up yet. The marked flush of decomposition when the bare fallow soil is moistened at the start of the rains has now been found to occur for the sixth time in succession.

THE USE OF THE RESPIROMETER FOR ASSESSING THE VALUE OF ANIMAL FEEDS

H. F. Birch

61. The ease with which the macro respirometer used in the previous studies measures the decomposition of organic material suggested its use in determining the decomposability of feeding stuffs to see to what extent this is related to their digestibility. Samples (0.25 g.) of known digestibility, kindly supplied by Dr. A. Rogerson of the East African Veterinary Research Organization, were mixed with sand (150 g.), moistened and put in the respirometer for 9 days. After this the amounts of carbon and nitrogen mineralized were determined. A very significant relationship was found between the magnitude of decomposition and (1) total digestible nutrients ($r^2=0.74$), (2) digestible crude protein ($r^2=0.82$) and dry matter digestibility coefficient ($r^2=0.66$). It was also found that only with feeds containing more than 14.75 per cent crude protein was mineral nitrogen released. The decomposition of mixed feeds was also studied. Cassava flour (low protein content) which hardly decomposed by itself, rapidly decomposed when mixed with groundnut cake, which liberated appreciable amounts of mineral nitrogen on decomposition. This influence of nitrogen supplement on the decomposition of the low protein feed parallels the increased digestibility that follows when low protein feeds are supplemented with protein. It appears that the macro respirometer should be of value in the preliminary assessment of the digestibility of feeds, both single and mixed. Decomposition in the presence of activated charcoal, which will adsorb the soluble decomposable nutrients, may help to differentiate within the broad relationships so far found.

STUDIES ON SOIL PHOSPHORUS

M. T. Friend

62. Investigation of methods for the fractionation of soil phosphorus has been continued using a set of 31 soils from fertilizer trials on wheat (Highland Fertilizer Scheme 1950).

63. The quantities of phosphorus extracted by an anion exchange resin were low (less than 10 p.p.m. P) and bore no relation to crop response to added phosphate. This was also the case with phosphorus extracted by 0.5 M sodium bicarbonate at pH 8.5. This latter method has been used with some success in the United States in predicting crop responses to phosphate fertilizers.

64. The phosphorus retention capacity of the above soils depended on the percentage clay content and on the value of the silica-sesquioxide ratio of the clay fraction; clays with the lowest ratio retaining the most phosphorus. The higher the percentage iron and aluminium in the soils the more phosphorus was retained.

65. Determinations of total phosphorus and organic phosphorus were made. Generally, wheat grown on soils with low total phosphorus (about 200 p.p.m. P) gave the highest responses to phosphate fertilizer and soils with high total phosphorus (500 to 700 p.p.m. P) gave low phosphate responses. On an average, the organic phosphorus accounted for 86 per cent of the total phosphorus. These results suggest that it is not the easily extractable forms of phosphorus that are important, but the reserves of phosphorus held in the soil. The conditions giving rise to mineralization and release of this reserve warrant further investigation.

THE DETERMINATION OF COPPER IN PLANT MATERIALS

M. T. Friend

66. On the recommendation of the Analytical Sub-Committee of the Pasture Research Specialist Committee which met at Muguga in February, 1958, methods of copper analysis in plants were investigated.

67. A published (Analyst. *80*, 514, 1955) colorimetric method using the reagent zinc dibenzyldithoicarbamate was investigated and used to determine copper in a variety of plant materials. The method proved reliable and fairly rapid and good agreement with spectrographic methods of analysis was obtained. Copies of the method were circulated to interested persons in East Africa.

A CHEMICAL LIGHT METER

M. T. Friend

68. In connexion with the work of the Physics Division on the effect of shade trees on tea, a short investigation was under-

taken to see if a simple and cheap chemical light integrating meter could be developed to take the place of expensive electrical meters. This would allow a large number of such meters to be distributed over the experimental area.

69. The basis of the method investigated is that anthracene, which is soluble in benzene, polymerizes in the light to di-anthracene, which is insoluble. The actual method used was to fill screw-cap bottles with a solution containing 5 grams of anthracene per litre of benzene, place the tubes in boxes masked by metal strips to reduce the amount of light entering the tube, and leave the tubes exposed to the sky for two to three days. The tubes are then removed, the contents filtered rapidly to remove the insoluble di-anthracene, an aliquot diluted 250 times with pure benzene, and the optical density of the diluted filtrate measured at the wavelength of 350 mμ. on the spectrophotometer.

70. These light meters were calibrated against a standard Kipp solarimeter connected to a Cambridge thread recorder. The residual anthracene concentration A was related to the total radiation received R, in gm. cal. cm^{-2} by the equation

$$R = 917.5 - 1362.4 \log A \qquad r^2 = 0.989.$$

This method agrees extremely well with the electrical, presumably because there is a strong correlation between the intensity of light in the range around 350 mμ. and the total radiation.

71. Unfortunately, although this method works extremely well, it has not been found possible to use it in the experimental work because of lack of suitably trained chemical assistants.

ANALYTICAL SERVICES: CHEMICAL

M. T. Friend, C. C. Hood and Leonard Nganga

72. The analyses of soils and plants submitted by various research officers and departments has continued. In all, 430 soils were received during 1958.

E.A.A.F.R.O. SOIL SURVEY SECTION

A total of 117 soils from Kenya and Tanganyika were analysed for pH, carbon, nitrogen, coarse and fine sand, silt, clay and organic matter.

E.A.A.F.R.O. CHEMISTRY SECTION

Twenty-eight local Muguga soils were analysed for carbon, nitrogen and pH in connexion with nitrogen conservation field trials.

E.A.A.F.R.O. ARBORETUM

In relation to tree growth, 63 soils were analysed for carbon and nitrogen.

E.A.A.F.R.O. PASTURE FERTILIZER TRIALS

Twenty-four grass samples from Muguga Farm were analysed for total nitrogen and phosphorus.

ELDORET EXPERIMENTAL FARM

Fifty soils from residual phosphate trials were analysed for pH, carbon, nitrogen, sand, silt and clay, and three forms of phosphorus.

E.A.A.F.R.O. SPECTROCHEMISTRY SECTION

Seventeen soils from several Kenya farms were analysed for pH and nitrogen in conjunction with other analyses by the Spectrochemistry Section.

E.A. IMPLEMENT AND TRACTOR TESTING UNIT

A profile consisting of six soil samples was taken from the test field at Nakuru and analysed for carbon, nitrogen, pH and mechanical analysis into five fractions.

SERERE, UGANDA

Twenty-five soils from a Phosphate Manurial experiment were analysed for pH, carbon, nitrogen and adsorbed phosphorus.

DESERT LOCUST CONTROL

The salinity of 89 soil samples from Eritrea was investigated. Determinations were made of chloride, total soluble salts and electrical conductivity on these samples. A further eight samples were analysed for different sand fractions and clay content.

HEIGHTS ESTATE LTD., ARUSHA

Five soils were analysed for pH, nitrogen, carbon and sand, silt and clay.

FORESTRY DEPARTMENTS

Fourteen soils from Kenya, Uganda and Northern Rhodesia were analysed for pH, carbon, nitrogen and phosphorus, sand, silt and clay.

PLATEAU WATTLE CO., ELDORET

Eight soils from fertilizer trials were analysed for pH, acid soluble phosphorus, adsorbed phosphorus, total and organic phosphorus in relation to responses of wattle trees to phosphate applications.

73. *Soil Carbon Determinations.* A set of a dozen East African subsoils have kindly been analysed for carbon by the dry combustion method at Rothamsted Experimental Station, Harpenden. For soils low in carbon (0.3 per cent and under), the dry combustion method gives values appreciably higher than the routine Walkley-Black method in use in these laboratories. Various modifications of the latter method have been investigated, such as heating to increase the amount of organic carbon oxidized and, whilst giving slightly higher values, the modifications still give low results compared to the dry combustion method.

ANALYTICAL SERVICES — SPECTROCHEMICAL

G. T. Chamberlain, A. J. Searle and C. A. Spinage

74. The Division has continued the analysis of soils and plants for bases and trace elements. Samples have been received from many sources in connexion with a wide variety of problems.

75. It has been possible to carry out many more analyses this year due to Mr. Spinage being trained in the trace element techniques at the beginning of the year and Mr. Searle returned from vacation leave in March. Bases have been determined in 264 soils, 29 plants and 14 blood samples, whilst trace elements have been determined in 169 plants and in over 280 extractions of 130 soils.

76. The modifications to the trace element methods initiated last year have been completed for the analysis of plant ash. These modifications include the introduction of a three-step filter instead of the rotating step-sector, the replacement of carbon electrodes by boron-free graphite, alteration of the waveband to include boron and silicon in the analysis, and the use of the "Respektra" calculation board for the evaluation of results. The outcome of these modifications is that the evaluation of the spectrograms from nine samples of plant ash involves considerably less work than was required previously for six samples.

77. To improve the stability of the microphotometer lamp intensity, a voltage regulator has been built to the design of Dr. A. Ure of the Macaulay Institute for Soil Research, Aberdeen, and this has been of considerable benefit.

78. *Bases in Soils and Plants.* A total of 213 soils were analysed for the Soil Survey Division of E.A.A.F.R.O., ten were from phosphate residual trials at Eldoret, two for the Forest Department, Kenya, and two for the E.A. Implement and Tractor Testing Unit. Six samples were from two termite mounds and were submitted by the Forest Department, Northern Rhodesia, via Ecologist, E.A.A.F.R.O. One mound showed an increase in bases and base saturation with depth while the other showed decreases. The remaining samples were for trace element analysis and bases were determined as part of routine examination.

79. The 14 blood samples were from grade and Zebu cattle. Examination showed that the high sodium/low potassium contents and vice versa obtained in other parts of the world for the two types were not present in this series of samples. The analyses were carried out at the request of Dr. Quarterman.

80. *Trace Elements in Plants. Pastures and Grasses.* Much attention is being paid to this class of work and samples have been analysed at the request of the Grassland Research Stations at

Kitale and Molo, Kenya, the Animal Health Research Centre, Entebbe, Uganda, the Experimental Farm of the Veterinary Department, Kenya, as well as samples from Muguga.

81. The 12 samples from Muguga were from a urea/phosphate fertilizer experiment on star grass being carried out jointly by E.A.A.F.R.O. and Dr. H. W. Dougall of the Grassland Research Station, Kitale. The samples represented two cuttings of each of the six treatments, the first being taken in October, 1957, following a dry period, and the second in May, 1958, in the wet season. It appeared that the molybdenum, nickel and zinc contents were higher in the wet season than the dry whereas the cobalt tended to show the opposite effect.

82. From the Grassland Research Station, Kitale, ten pairs of samples were analysed, being, in each case, healthy and unhealthy samples of clover (*T. sempilosum, T. repens Bameda, T. repens Louisiana* and *T. pratense*), two pairs of samples of lucerne (*Medicago sativa*), a tree lucerne (*Cytisus prolifer*), Lubam clover (*Melilotus alba*), molasses grass and elephant grass. No systematic differences were observed between healthy and unhealthy samples.

83. Continuing the investigation of the pastures for the Veterinary Department Experimental Farm, Naivasha, samples of grass have been received at monthly intervals. It is hoped that these will provide data which, when coupled with milk analyses, might yield information regarding milk taint. No severe taint was observed at Naivasha during the year so that it was not possible to obtain milk for analysis. This must now await the rains of 1959.

84. Nine pasture samples from three farms in the Rift Valley, of similar situation to the Experimental Farm have also been analysed.

85. The samples from Uganda were two *Digitaria ternata* and two *Setaria setulosa* from good and bad pastures in the Karamoja. No significant differences were observed between the samples from the good and bad areas. A sample of elephant grass and Russian comfrey from Entebbe were also analysed.

86. *Other Plants.* Mr. Pinkerton of the Scott Agricultural Laboratory, Kenya, submitted six samples of citrus leaf (three healthy and three unhealthy) from the Machakos area where a zinc deficiency was suspected. Analysis showed no difference in the zinc

contents of healthy and unhealthy leaves but the boron contents of the latter were very much higher (160–190 p.p.m. in B) than the healthy samples (65–80 p.p.m.). Four further samples were analysed from trees injected with zinc. For successful complete injection, healthy leaves showed the high zinc content of 177 p.p.m., while for unsuccessful injection, chlorotic leaves contained 16 p.p.m. Zn. The corresponding boron figures were 116 p.p.m. and 163 p.p.m. respectively. For solid zinc injection, the figures for healthy and chlorotic leaves were 103 p.p.m. Zn, 68 p.p.m. B and 40 p.p.m. Zn and 122 p.p.m. B respectively.

87. It was recorded in the last Annual Report that zinc deficiencies had been found in coffee leaves which the Coffee Research Station, Ruiru, has shown to be due to the application of a fungicide. A further 21 samples have been analysed in connexion with this investigation. Eight of these samples were from the first (youngest), second, third and fourth pairs of leaves from a shoot. The results were as follows:—

	Control Plants p.p.m. Zn	*Deficient Plants p.p.m. Zn*
1st Pair	31 ...	13
2nd Pair	20 ...	14
3rd Pair	19 ...	9
4th Pair	7 ...	8

The remaining samples were from plots to which other fungicides had been applied and zinc contents from 8-14 p.p.m. were obtained. These were lower than one control sample (22 p.p.m.) but a duplicate control gave only 12 p.p.m. Zn. One sample from a plot receiving a heavier application of fungicide contained 5 p.p.m. Zn. A further 18 samples from a zinc chelate experiment are being analysed.

88. More analyses have been carried out on samples from the very acid soil area at Nachingwea, Tanganyika. Where in previous years sorghum was grown, cashew has now been established and leaf samples from the extremely acid sites again showed lower calcium, magnesium and molybdenum contents than better sites and all molybdenum contents were appreciably lower than that of a sample from another farm where cashew was growing well.

89. Further field experiments have been carried out at Nachingwea using heavy applications of lime to plots of maize and groundnuts. For groundnuts, one and three tons of burnt lime

produced systematic increases from 0.025 to 0.1 p.p.m. molybdenum in the leaf and there was some indication of a reduction in the uptake of manganese from 620 to 400 p.p.m. No other element showed any progressive variation in content. For the maize samples from all three blocks of the experiment, molybdenum showed a progressive increase from approximately 0.1 to 1 p.p.m. with increase in lime, but the manganese contents were irregular.

90. Another experiment with maize involving nitrogen and lime on a better soil produced no changes of importance in the composition of four-leaf samples. From Nachingwea a total of four samples of cashew leaf, six of groundnut leaf and 13 of maize leaf were analysed.

91. Seven samples of wattle leaves were submitted for analysis by the Plateau Wattle Co., Eldoret, Kenya, being three pairs of healthy and chlorotic samples from the Nandi–Kipkabus area with an extra healthy sample from Eldoret. Of the 22 elements determined in each sample, only magnesium showed a persistent change in content between chlorotic and corresponding control. The values obtained were 0.13 per cent chlorotic and 0.28 per cent control, 0.07 per cent and 0.21 per cent, and 0.01 per cent and 0.26 per cent Mg for the three pairs with the Eldoret sample showing 0.45 per cent Mg.

92. For the Horticultural Research Station, Thika, Kenya, seven samples of pineapple leaf were analysed, these being from a trace element trial in which iron and manganese chelates had been used in conjunction with ammonium sulphate. Very little change in the iron contents of the leaf was obtained and while there was a rather greater change in the manganese values, this did not appear to be attributable directly to the application of manganese.

93. In the Plant Quarantine Station, Muguga, sugar cane was observed to be showing signs of manganese deficiency although the cane was growing in a mixture similar to that which produced a manganese toxicity in sweet potato (Annual Report, 1955/56). The manganese results obtained from three apparently healthy and three unhealthy leaf samples were all in the range 2,000–5,000 p.p.m. but there was no difference between the two groups. The iron contents of the unhealthy samples were slightly lower (200–300 p.p.m.) than the healthy (300–500 p.p.m.) and it might be the case that the lower iron contents were just sufficient for the visual symptoms of what, in fact, was a manganese toxicity to appear.

94. Miscellaneous plant analyses carried out have included seven samples of leaf from acacia and other tree species from the Muguga Arboretum, a sample of carcass meal for the E.A.A.F.R.O. Farm Manager, a sample each of cattle dung, goat dung, molasses grass and wheat for the Nyasaland Department of Agriculture and two coffee leaf samples for the Coffee Research Station, Lyamungu, Tanganyika.

95. *Soil Analysis.* To provide supplementary information to pot tests at the Scott Agricultural Laboratories, 19 soils were analysed for trace elements at the request of Mr. Pinkerton. It was found that zinc determinations using an acetic acid (0.5 N) extract gave a close correlation to zinc determined by the Pinkerton using *aspergillus niger*. Also a number of these soils showing on analyses a low zinc value corresponded to those giving zinc responses in the pot tests. These soils were also extracted using N. ammonium acetate (pH 7) and E.D.T.A. (Ethylene diaminetetra-acetic acid) and the results are being examined along with those of other samples to discover whether there is any correlation in the amounts of molybdenum, zinc and other elements extracted by these two reagents.

96. At the request of Dr. Mehlich who is working at the Scott Agricultural Laboratories on phosphate retention in soil, analyses were carried out on hydrochloric/sulphuric acid extracts. These revealed a general similarity to the acetic acid extracts for such elements as cobalt and nickel but the extraction of zinc, vanadium and lead was rather greater than by acetic acid.

97. From the Kawanda Research Station, Uganda, 112 samples from profiles of the more important Uganda soil types have been received and over 80 of these have been analysed using both acetic acid and E.D.T.A. extraction. The results will be studied in detail in co-operation with Dr. Chenery of the Kawanda Research Station.

98. In the last Annual Report, mention was made of the high molybdenum content found around the shore of Lake Naivasha. Analyses have now been made of similar samples from the western side of Lake Naivasha, from Lake Elementeita and Lake Nakuru. The western Naivasha samples showed did not show an increase in molybdenum content but those from Elementeita increased from 0.1 p.p.m. in the higher areas to 0.6 p.p.m. Mo at Lake level and 0.7 p.p.m. old lake bed. The Lake Nakuru samples from the southern end of the lake showed only a very slight increase from 0.04 to 0.06 p.p.m.

99. Other soil analyses carried out here have been on samples from the Grasslands Research Station, Molo, from the Soil Survey Division, E.A.A.F.R.O., and from Arusha and Nachingwea for the Tanganyika Department of Agriculture.

100. *Advisory Work and Visits.* Close contact has been maintained with the Sisal Research Station, Mlingano, Tanganyika, and during vacation leave it was arranged that Mr. Osborne, Spectrochemist at Mlingano, and I should synchronize our visits to the Macaulay Institute, Aberdeen. At the Macaulay Institute, discussions were held on spectrographic techniques and the methods of overcoming difficulties arising in setting up trace element methods of analysis. Dr. Mitchell and his staff in the Department of Spectrochemistry of the Macaulay Institute were most interested to hear of the results being obtained in East Africa. Visits were also made to spectrographic laboratories at the East and West of Scotland Agricultural Colleges, Rothamsted Experimental Station, East Malling Research Station, the National Agricultural Advisory Service, Bristol, Tropical Products Institute and other laboratories in which a valuable interchange of views was held. Equipment manufacturers were also visited and of particular interest were the developments taking place in direct reading spectrochemical equipment.

SOIL MICROBIOLOGY

J. W. Millbank and M. A. Ledger

101. The Microbiology Section has continued to work on the nitrogen cycle in Muguga soil, with particular attention being devoted to nitrification and the legume-Rhizobium symbiosis. Work on non-symbiotic nitrogen fixation has been initiated.

102. *Nitrification.* Studies on the process of nitrification have been continued using the same soil perfusion technique as described in the 1957 Annual Report. Advances achieved since the preparation of that Report only will be recorded here.

103. *Soil Reaction and Nitrification Rate.* A more detailed study has been made of the effects of buffers other than calcium carbonate, namely magnesium carbonate and mono- and di-calcium phosphates ($Ca(H_2PO_4)_2$ and $CaHPO_4$). Magnesium carbonate added to the soil proved particularly effective in holding the pH of the perfusing solution between 8.0–8.5, but it caused an almost quantitative conversion of the added ammonia to nitrate before any nitrate was formed.

104. The phosphates proved less effective in maintaining a constant pH in the perfusing solution than did calcium carbonate. $CaHPO_4$ was the more satisfactory; it maintained a pH around 6, and enabled a fairly rapid and complete conversion of ammonia to nitrate to occur without any transient accumulation of nitrite. The phenomenon of nitrite accumulation is in all probability a pH effect, for in another experiment to be described later, a greatly reduced amount of calcium carbonate was added to a soil column by accident. The pH fell to about 6 from the expected 7.2–7.5, and very little nitrite accumulated (about 20/ μg./ml.).

105. The soil used in all these experiments was either taken from beneath a Kikuyu grass sward, or else from a similar soil in other locations which had not had grass cover for some years. In every case the results were virtually identical, there being no apparent inhibitory effect due to the Kikuyu grass.

106. *The Effect of Rainfall on the Lag Phase in Nitrification.* Two experiments were carried out with a soil under Kikuyu grass, one after the "long rains" had been in progress for about four weeks, and the other three weeks later. The soil was thoroughly moist, with a moisture content of 30 per cent, plant growth was rapid, and the levels of nitrate and ammonia-nitrogen were both low, each being about 4 p.p.m. of N., due in all probability to their rapid absorption by the grass roots. It was found that when these soils were put in the perfusion apparatus the length of the lag before added ammonia was being nitrified at its maximum rate was about the same for the two samples, and differed from the behaviour of a soil initially dry, in that the transitory accumulation of nitrite was much less pronounced. One may tentatively conclude that even after seven weeks of moist conditions, the nitrifying organisms were still physiologically somewhat inactive, presumably due to lack of substrate through the ammonia being readily absorbed by the grass roots. The Nitrobacter organisms, however, seem to be less moribund in the moist than the dry soil. The experiment is to be repeated at the next opportunity on a bare fallow soil.

107. *The Effect of Inhibitors.* The only inhibitor studied was allylthiourea. This chelating agent has been found by Lees, and Hofman and Lees, to stop ammonia oxidation in cell suspensions, but little is known of its effects in soil. Soils enriched with nitrifying bacteria by pre-perfusion with ammonium sulphate were used. The control soils converted all the added ammonia to nitrite in eight days. Soils through which 10^{-3}M. allylthiourea was being

perfused with the ammonium sulphate did not commence to nitrify until 18 days had elapsed, and 10^{-4}M allylthiourea held up the commencement of nitrification for six days. The inhibitor is presumably destroyed by the soil heterotrophs. Upon its destruction, nitrification was enabled to recommence.

108. *Isolation of Responsible Organisms.* Work is proceeding along the lines of Meiklejohn, with the objective of isolating the nitrifying organisms in pure culture. So far, suspected colonies of *Nitrosomonas* have been obtained on silica gel plates.

109. *Non-Symbiotic Nitrogen Fixation.* The presence of anaerobic non-symbiotic nitrogen fixing bacteria in Muguga soil (probably *Clostridium Pasteurianum*) has been demonstrated by incubating flasks of sucrose media inoculated with dilutions of soil pasteurized at 80° for 15 minutes in an atmosphere of nitrogen and hydrogen. After 14 days, 2.2 to 2.4 mg. N was present in the inoculated flasks, compared with 0.8 mg. in the controls (the inocula contained 25–100 μg. N, depending on the soil used). Similar results were obtained using media containing sodium thioglycollate, which obviates the use of McIntosh and Fildes' Jars. It is proposed to pursue this aspect of the nitrogen cycle, under both aerobic and anaerobic conditions, using soil perfusion units, to try to assess its agricultural importance in raising the nitrogen status of the local soils.

110. *The Legume-Rhizobium Symbiosis. Field experiments with Lucerne.* The experiment on the persistence of an introduced strain of lucerne Rhizobium in the Muguga soil has shown that it can only be expected to persist for about a year. Although it formed what appeared to be effective nodules with lucerne on this soil, and the inoculated plants started growing rather better than the uninoculated, yet neither their yield nor their nitrogen control was noticeably higher than the unnodulated. This could have been due to the soil having quite a high content of organic nitrogen, so it is probable the uninoculated plants did not suffer from a lack of nitrogen. The strain of Rhizobium used was proved to be effective in fixing nitrogen when the lucerne was grown in a sand-vermiculite mixture. This experiment also showed conclusively that nodular activity is intimately connected with the moisture content of the soil, and quantitative experiments on this aspect are planned.

111. The experiment in conjunction with the Chemistry Department on the ability of certain tropical legumes to enhance

the nitrogen status of the soil, is continuing. It is still too early for any definite conclusions to be drawn.

112. *Greenhouse Experiments.* The experiments to study the comparative effectiveness of various strains of Rhizobium by growing the suitable legume in various East African soils, diluted with a sand-vermiculite mixture, have not proved practical as yet, because sterilizing the soil before use to kill the indigenous Rhizobia renders it toxic to plant growth for reasons as yet unknown; although inoculated plants growing in sand-vermiculite mixtures alone grew well and gave plants as good as those plentifully supplied with potassium nitrate.

SOIL SURVEY

R. M. Scott

113. Mr. Gethin Jones retired at the end of March, after having completed 26 years in East Africa. Prior to joining E.A.A.F.R.O., he had spent 20 years with the Kenya Department of Agriculture and his retirement has been a great loss to this Division.

114. *2nd Provisional Soil Map.* Prior to the retirement of Mr. Gethin Jones, the work of this Division was concentrated on completing the Kenya and Tanganyika portions of the 2nd Provisional Soil Map and the accompanying memoir. Certain areas of the Kenya and Tanganyika portions of the map have been left blank. These blanks in the main represent areas where road communications are few or non-existent and also are uninhabited or sparsely populated. It was felt that at present it was better to concentrate on the more populated areas where communications were good than to spend time, which would be out of proportion, on these blank areas. As has been stated in previous Annual Reports, the Uganda portion of the map is being undertaken by a soil survey team under the direction of Dr. E. M. Chenery, Chief Research Officer, Uganda. This survey has progressed far faster than was anticipated and it is now hoped to publish the 2nd Provisional Soil Map next year.

115. As the Mount Kenya area had not been visited previously, a rapid reconnaissance soil survey was carried out round the Mountain. This included two detours, one to the Nyambeni Hill and the other to the arid area around Garba Tula. These two detours proved very interesting as they showed highly

contrasting soils ranging from those found under hot, arid conditions to high rainfall areas with a cool climate. The Nyambeni Hill, like Mount Kenya and the eastern slopes of the Aberdare Mountains, shows a sequence of soil zones which appear as wetter and cooler conditions prevail. At the foothills "medium humic red soils" were seen. With increasing rainfall and altitude, these passed into "high humic red soils" and it is within these two zones that the main agriculture of the district is carried out. In the wetter and cooler areas, "high humic yellow brown friable leached soils", or "bracken soils" are situated. These soils constitute one of the main problem soils of Kenya, since although they are well drained, receive adequate rainfall, and are rich in organic matter, they have been highly leached and contain few exchangeable bases. The African farmers practise a rotation of approximately one year cultivation, ten years fallow. They appear, however, suitable for wattle and tea production, since both these crops grow on similar soils at Limuru.

116. The soils of the arid areas, however, were very different to the last-named soils, since they were all highly saturated. In the vicinity of Isiolo and extending for approximately 60 miles eastwards toward Garba Tula, the area has been classed as "mainly lava boulders". As explained under the section dealing with soil classification these conditions refer to a dominant feature of the land surface rather than a soil class. On dry stream and river courses, a dark brown calcareous clay loam, colluvium derived, occurred. Near Garba Tula, slightly calcareous red plain soils were seen together with small pockets of red desert soils with massive limestone horizons. These slightly calcareous red soils are very similar to the low, humic red soils seen in the Voi area but contain smooth and irregular $CaCo_3$ nodules. They were found overlying both the basement complex and tertiary sediments. These soils are probably relic soils of the past more humid climate. These last three named soils are probably among the main soil types for the arid Northern Frontier Region.

117. On the Northern slopes of Mount Kenya, recent ash soils and youthful volcanic ash soils with a pedalfer trend were seen. The latter were seen to have some of the "Kinankop vlei soils" associated with them. Otherwise the sequence of soil zones pertained.

118. *Ash Soils.* It has proved difficult in the past to recognize highly weathered ash soils and ash contamination in the field. While comparing data to correlate the "Hydrol humic

latosols" of Hawaii and the "High humic friable leached soils" from Fort Essex, it was noticed that the ratio between the B.E.C. at pH 4.5, i.e. the B.E.C. due to the permanent negative charge of the clay, and the difference between the B.E.C. at pH 7 and the B.E.C. at pH 4.5, i.e. the B.E.C. due to the pH dependent charge, was less than 1 for the upper horizons of the soil, while at the lower depths, where a sticky red clay occurred, the ratio altered to 3.5. The upper part of this soil was thought to be ash derived while the red sticky clay below was thought to be derived from hard rock. As a result of this, 38 samples of different soils ranging from heavy black clays to recent ash soils were compared in this way. With the exception of two samples, the remaining 36 results were as follows:—

for ash soils the ratio was less than 1;

for soils where there was thought to be ash contamination the ratio was just over 1;

for soils which were not ash derived nor had any ash contamination, the ratio ranged from 2.5 to 6.

The two exceptions were non-ash soils which had a ratio of 1.7 and 1.2. Both these soils had very low B.E.C. It is hoped that that this method may help in identifying ash-derived and ash-contaminated soils. In conjunction with this work, samples have been sent to the materials branch of the Ministry of Works, who have kindly offered to identify the clay minerals by differential thermal analyses.

119. *Soil Surveys.* At the request of Dr. Pereira, Deputy Director of E.A.A.F.R.O., a rapid reconnaissance soil survey was carried out on the Sambret Catchment to ascertain whether there were any soil differences between the bamboo area at the top of the catchment and the forested area lower down. It was found that there were no essential differences between the soils in the bamboo and that of the tall forest other than those to be expected from the immediate effects of the vegetation cover and the bamboo boundary is the result of past major fires. An interesting feature of this survey was the presence of the dark humic horizons found below the surface soil. These were thought at first to be similar to the "dark-horizon latosols" of the Belgian Congo, but, on investigation, it was found that these humic horizons contained large amounts of charcoal and in one case a piece of obsidian, which may have been an artifact, showing that these humic layers were not caused by a pedological process but had been buried. As the soil above

the humic horizon showed different characteristics to the soil found below the humic horizon, and these characteristics were similar to the ash soils, it was assumed that these humic horizons had been buried by ash. This was verified when comparing the ratio of the B.E.C. at pH 4.5 and pH 7.

120. In 1952 a start was made in preparing a detailed soil map (scale 1:50,000), of the Nairobi–Thika Districts using air photographs in conjunction with ground reconnaissance. This survey was continued when time permitted until work began on the 2nd Provisional Soil Map. During the year two requests were made for copies of this map. The first request came from the Nairobi County Council, who requested a copy for Town Planning. The other request came from the Hydrology Section of the Ministry of Works, who asked for a copy for their report on the irrigation potentials of the Upper Athi Catchment. As there will probably be a greater demand in the future for this map, it is proposed to complete it in 1959.

121. Help has also been given to the Hydrology Section in describing the soils and delineating their approximate boundaries as far as they are known, of the Uaso Nyiro basin in the Northern Frontier District for another irrigation potential report.

122. Visitors. Dr. T. L. Alexander made a visit to E.A.A.F.R.O. in the early part of the year, and an interesting day was spent in the field with him. Dr. Gunn, of Alexander Gibb and Sons, called and discussed soils of the Upper Tana Basin.

ECOLOGY

C. G. Trapnell

CLIMATIC TYPES OF VEGETATION IN SOUTHERN KENYA

123. Investigational work during the year was largely concerned with the determination of climatic types of vegetation in Southern Kenya. Vegetation reconnaissance in this region was originally begun with the object of co-ordinating the ecological zones employed in the several provinces by officers of the Agricultural Department. Traverse work with aneroid observations was continued in Meru, Embu, Kitui and Kiambu Districts. This brought field work to the point at which a preliminary overall classification of vegetation types could be arrived at, and a study of the records was made for this purpose. Full descriptions are now being prepared. This work at the same time made it abundantly clear that no simple zonal correlation of the types found in various parts of this region is possible. The region must, in fact, be divided into three sectors with widely divergent patterns of vegetation. A preliminary study of the climatic factors involved in these divergences has brought to light a clear correlation with a simple climatic factor, the amount of rainfall per thousand feet of altitude. This factor, while it is in no sense regarded as a comprehensive climatic index, has thrown new light on the distribution of vegetation in this part of Kenya and has a direct bearing on the interpretation of climatic regimes.

Vegetation types

124. In a populated region a vegetation grouping which is to be employed for correlation with climatic factors must of necessity combine primary or climax vegetation types with secondary types resulting from clearing, cultivation and similar factors. Three problems arise in this approach: the relating of secondary cultivation savannas to the forest types they have replaced; the assessment of vegetation which has been subjected to encroachment by alien species as a result, particularly, of overgrazing; and the treatment to be accorded to "subclimax" or presumed subclimax types which have been influenced in most cases by a past history of burning.

125. The first difficulty has been to a considerable extent overcome by a combined study of relict forest elements and of herbaceous species replacing forest remnants in secondary regrowth. A range of forest indicators has been arrived at by this means and several types of derived cultivation savanna can now be determined. The processes of bush encroachment in grazing lands have already been referred to in the previous annual report. Here also it is commonly possible to trace remnants of the original vegetation. The most difficult issue is the treatment of presumed subclimax types, for example montane grasslands, montane *Acacia* vegetation and several types of *Combretum* savanna. The principle which has been adopted here is that unless and until they can be demonstrated to have replaced a different vegetation association such types are best treated as though they were primary.

126. In brief outline the provisional grouping arrived at on this basis is as follows:—

Alpine heath and moorland.

Montane grassland with forest outliers.

Montane bamboo thicket.

Montane rain forest and associated types:

- Montane rain forests.
- Montane transition forest.
- Montane high-rainfall cultivation savanna.

Intermediate rain forest and associated types:

- Intermediate rain forests.
- Intermediate high rainfall cultivation savannas.

Sclerophyll (podo. and cedar) forests and derived vegetation:

- Montane sclerophyll forests.
- Sclerophyll forest scrub and scrub-grassland.

Semideciduous forests and associated types:

- Intermediate semideciduous forest.
- Intermediate light-rainfall cultivation savanna.

Sclerophyll (evergreen) and semideciduous bushland types:

- High-level sclerophyll bushland and scrub-grassland.
- Intermediate sclerophyll thicket and cultivation savanna.
- *Tarchonanthus* and *Acacia*-sclerophyll scrub transition types.
- *Combretum*—sclerophyll scrub transition types.

Deciduous broad-leaved savanna types:

High-rainfall *Combretum* and allied savannas.
Mid-*Combretum* and allied savannas.
Dry *Combretum* savannas.

Deciduous thorn-woodland and savanna types:

Montane *Acacia* woodland and savanna.
Intermediate (high-level) *Acacia* savannas.
Transitional *Albizia—Acacia* savanna.

Deciduous thorn-bushland types:

Dry *Acacia* and *Commiphora* bushlands.
Transitional desert *Acacia* bushland.
(Desert thorn-scrub types proper not included.)

Edaphic (impeded drainage) grassland and savanna types:

Montane grasslands with impeded drainage.
Bush-groups grasslands with impeded drainage.
Drainage-plain grasslands in broad-leaved savanna areas.
Acacia savannas and associated grasslands on black clay plains.

Only the main heads, of course, are given here. Altitude and rainfall designations have been used as a matter of convenience, with allowance for extension to coastal lowland types, but the terminology is necessarily provisional. It should be emphasized that this is not a land-use classification. Zonal grouping of types for land-use purposes is not proposed until a full meteorological check has been completed.

Climatic series

127. This summary covers what is in fact an exceptionally varied pattern of vegetation. Southern Kenya is subject to marked orographic variation of rainfall. There is a well-known general tendency for rainfall to increase with altitude, and vegetation changes proceed correspondingly in series from lower, hotter and drier conditions to higher, cooler and wetter conditions. What, however, is not generally realized is that these sequences vary greatly from place to place. There is not a single simple climatic series of vegetation types in a uniform zonal arrangement. There are at least three distinct sequences involving different vegetation types.

128. It was pointed out in the previous annual report that there is a marked break between the vegetation types found in the Lake Victoria region and those of the region to the east of it. The line of division passes down the west flank of the Cherangani range to the east of Kitale, circuits west of Eldoret towards Mosoriet, passes through the western portions of the Tinderet and Mau forests and thence south-west along the western side of the Chepalangu forest. The regions so divided may be referred to for convenience as the Western Decline and the Rift Highlands respectively.

129. A further such division has since been found to exist between the vegetation sequence of the central Rift region and the types found on the broad slope towards the Indian Ocean to the east of it. The line in this case runs from the north side of the Nyambeni range (north-east of Mount Kenya) just north of Meru and over Mount Kenya, encloses Nyeri and thence runs down the Aberdares and Kinankop through Limuru to the neighbourhood of Nairobi. From Nairobi it doubles back to Ol Doinyo Sapuk and thence resumes a less definite southerly course through the Machakos hills. The region to the east of this line is referred to as the Eastern Decline. Within it is found a further series of vegetation types which, while they are in several respects analogous to those of the Western Decline, contain a number of differences.

130. The outstanding feature of the Western Decline is that its vegetation types are in a large measure related to those of Uganda. The climatic series here includes montane rain forest and transition forest, montane *Acacia* woodland, intermediate rain forest, high rainfall *Combretum* savanna, a *Combretum*-sclerophyll scrub transition and the remnant sclerophyll thickets of the lake-shore region. With them, of course, are to be included the several types of cultivation savanna associated with them. The vegetation sequence of the Rift Highlands sector, on the other hand, may prove to have affinities in parts of Ethiopia. The main series in this case proceeds from montane grassland with forest outliers down through several variants of montane sclerophyll forest to high-level sclerophyll bushland and scrub-grassland with *Tarchonanthus* incursions, to intermediate high-level *Acacia* savanna and lower dry *Acacia* bushland. Dry vegetation types ascend to much higher levels than in the regions to either side of it. By contrast the series on the Eastern Decline begins again with montane rain forest and derived cultivation savanna, but passes downwards into other types of cultivation savanna associated with remnants of

intermediate rain forest or semi-deciduous forest according to local rainfall conditions. These in turn give way to mid-*Combretum* and dry *Combretum* savanna and dry *Commiphora* bushland. The sequence has affinities with that of some adjoining parts of Tanganyika.

131. The only noteworthy exceptions to this three-fold division are that a few vegetation types straddle the dividing lines —montane bamboo thicket is the main instance—or have outlying occurrences within the central Rift region, such as the recurrence of montane *Acacia* vegetation about Nakuru. Apart from these two cases the exceptions occur in the Rift area referred to below as the Baringo enclave. This includes occurrences of *Combretum* and *Combretum*-sclerophyll transition types and of transitional *Albizia-acacia* savanna among its departures from normal series.

The rainfall-altitude ratio

132. It became clear that this differentiation into three major vegetation sequences must be related to differing combinations of mean annual rainfall and altitude. This supposition was verified by applying a simple factor, the number of inches of rainfall per 1,000 feet of altitude, to representative rainfall recording stations within each of the regional divisions. The sample figures indicated that stations on the Eastern and Western Declines enjoyed high rainfall ratios, falling jointly between 6 and 16 inches per 1,000 feet, whereas those in the Rift Highlands sector had only 3 to 6 inches. The only major exception was an enclave in the Rift sector occupied by the Baringo and Elegeyo basins, where the factor rose to between 7 and 8; this is an area in which dry types of vegetation occur under higher rainfall than elsewhere. This correlation was then fully checked by Dr. J. F. Griffiths of the E.A. Meteorological Department, who produced computations of the ratios of some 550 stations plotted on a map scale of 1/250,000. His plotting confirmed that, with the exceptions of the Baringo enclave and of two other stations at low altitudes, the dividing lines drawn between the three major vegetation regions agree very closely with the isogram for the 6-inch ratio.

133. There is therefore a significant climatic break, which may be referred to as the Rift Highlands rain gap, which has a major influence on the distribution of vegetation. Affected, very probably, by topography, it lies across the meeting of differing seasonal regimes, those of the Lake Victoria and upper Nile basin

regions on the one hand and of the ocean hinterland on the other. Their influence may be reflected in the differences in vegetation between the Eastern and Western Declines. Between them is a marked fall-off in orographic rainfall, resulting in different rainfall-temperature relations. How significant this fall-off may have been in Kenya may be inferred from a comparison with the population map of the territory. It will be seen at once that the main concentrations of population follow the Eastern and Western Declines. In the Rift Highland region, where the rainfall becomes sufficient for the usual tropical cereals, the greater altitude begins to be a retarding factor. It may well have been partly for this reason that the Rift Highland region lay vacant save for the incursions of pastoral tribes.

Vegetation Map

134. It is hoped that this work will lead on to a vegetation map of Southern Kenya, prepared with a view to delimiting climatic zones of vegetation for land-use purposes. Arrangements for this purpose have been made with the Directorate of Overseas Surveys and the Department of Agriculture. The projected map would involve air-photo interpretation and would be on a scale of 1:250,000. A detailed co-ordination with climatic data is contemplated.

MICROMORPHOLOGY OF RED EARTHS

135. Work on microstructures, reported last year, was continued with check examinations of profile material in the Soil Survey Division's collection. The indications at present appear to be that the simpler fragmental structures may be associated with relatively juvenile soils, being found in areas of tectonic disturbance and dissection or on recent volcanics, while the minutely granular types at the opposite end of the series have been mostly found on older land surfaces. More work, however, remains to be done on this subject. The study will be resumed when Kenya vegetation descriptions have been completed.

PLANT IMPROVEMENT AND PROTECTION

CASSAVA BREEDING FOR RESISTANCE TO MOSAIC AND BROWN STREAK VIRUSES

(1) *A Review of Twenty-one Years' Work*

L. R. Doughty

136. At the time this work started, in 1937, there were four species of *Manihot* available for study: (1) *M. utilissima,* cassava; (2) *M. glaziovii,* ceara; (3) *M. dichotoma* and (4) "tree cassava".* There was a fairly wide range of clones of *M. utilissima* available that had been tested for resistance to mosaic; resistance ranged from moderate to fully susceptible when the clones were classified on the basis of period of healthy growth during exposure to conditions conducive to a very high possibility of infection. *M. glaziovii* is susceptible to mosaic but has a marked ability to recover from infection, and produces new leaves free from any symptoms of mosaic. *M. dichotoma* is resistant to mosaic and the behaviour of tree cassava is similar to that of *M. glaziovii.* All three species have a tree-like form and woody fibrous roots, in contrast to *M. utilissima* which is shrubby and has tuberous roots. The various cassava clones cover a fairly wide range in habit of growth, in yield of root, and in the shape, size and palatability of the root.

137. The first stage of the work was to make interclonal crosses of cassava and interspecific crosses between cassava and ceara, dichotoma and tree cassava. Some of the cassava interclonal crosses were again intercrossed, with some increase in resistance to mosaic infection. In fact some of the 37- and 40-series have shown adequate resistance to mosaic and agricultural qualities of sufficient merit to warrant their general distribution in up-country areas, where brown streak is not a menace. In the coastal region of Kenya, Tanganyika and Zanzibar, however, none of these cassava hybrids has a high enough degree of resistance to mosaic and brown streak to warrant its retention.

138. The first generation interspecific hybrids were all tree-like in form and fibrous-rooted. Hybrids between ceara and cassava and tree cassava were reasonably fertile (sexually) and reasonably

*A fairly common local plant, possibly a natural hybrid between cassava and ceara.

easy to propagate from cuttings. The cassava—*dichotoma* crosses were, however, shy seeders and difficult to propagate vegetatively. A few seeds were later obtained from these F1's after open-pollination, and the rooting of cuttings of later generation seedlings and back-crosses improved, so that it was possible to test the progeny in field trials.

139. For each interspecific cross the F1 generation was back-crossed to different cassava clones, in an endeavour to restore tuberous roots; and thereafter successive generations were back-crossed and continual selection exercised for resistance to mosaic combined with yield and other desirable qualities. The ceara × cassava derivatives responded fairly rapidly to this treatment and, in the third back-cross generation, a few clones were obtained that have proved very satisfactory as regards mosaic resistance, yield and palatability in the coastal region and fairly satisfactory in respect of resistance to brown streak. Tree-cassava derivatives were much less satisfactory and *dichotoma* × cassava derivatives, whilst giving satisfactory resistance to mosaic, proved refractory in restoration of yield and resistance to brown streak.

140. Other interspecific crosses made at later dates were with *M. saxicola, M. catingae* and *M. melanobasis*. Derivatives of the first two crosses did not prove very promising, but the *melanobasis* derivatives have already proved outstanding from the point of view of yield but rather deficient in mosaic resistance. Field trials with the early back-crosses of *melanobasis* indicated a fairly high degree of resistance to brown streak; but in later trials, particularly those of longer duration, this resistance was not fully sustained.

141. Since 1953 most effort has been directed to inter-crosses between the clones that have proved outstanding in the coastal area; and latterly some effort has been devoted to producing a variety, with adequate disease resistance and yield, but having very bitter roots to deter pig. As a result of the penultimate stage of the work some 58 clones have been retained after short-term trials for assessment after a longer term in the field and 44 have survived to the stage of the first resistance trial.

142. Serious difficulties have arisen in selection for bitterness owing to very wide variations that are apparently connected with site, age and time of digging. Tasting at the harvest of resistance trials has given ranges from sweet to bitter for the same clone in different replications; and a similar range of results has arisen

from tasting of trials harvested at different stages of maturity. Some of the selected clones have, however, reached the stage when material is available for a practical "pig test".

143. The present position may be summarized as follows: The original hope that complete immunity might be obtained has not been realized; but a high level of resistance has been obtained. Thus, for the exacting conditions at the coast, three clones, all derivatives of ceara, have proved very superior to anything hitherto cultivated and are being extensively distributed: these are 4697/4, 46106/27 and 4763/16. Five others that have not yet reached the distribution stage but are nevertheless very promising have also been issued to Departments of Agriculture in this region, viz. 5315/39, 5317/21, 5318/34 (ceara), 5342/1 (*dichotoma*-ceara) and 53121/22 (tree-ceara). Still under test and of only limited distribution are the survivors of the 54-, 55- and 56-series of crosses. Twenty-two clones from 54- to 55-series were included in a long-term trial, established early in 1958 at Matuga, Mombasa, by the Department of Agriculture. On completion of the 1958 trials at Amani only five of these 22 clones were retained, but four others, not represented at Matuga, one 54-series and three 55-series, were kept. There are also seven survivors of the 56-series that have not yet been issued for field trial, bringing the total number of clones, from this line of crosses, retained at Amani for issue to 16.

144. Amongst these clones varieties suited to most conditions in the coastal region should be found. It is unlikely that any one clone will be successful in all soil types and in all climatic zones. In the Tanga Province, for instance, the clone 46106/27 is extensively used on the sandy coastal soil and 4763/16 on the red soil of the hinterland. In Zanzibar it is found that clones suitable for the clove soils are not adaptable to the "Kinongo" soil.

145. For up-country areas where mosaic is less virulent and brown streak rare or non-existent, the amount of material available for trial is embarrassing. General issue has not been made owing to the possibility of disseminating brown streak. Extensive collections have, however, been established at Kakamega and Ukiriguru, under special conditions for brown streak control. Subject to a clean bill of health on final examination, these will then be available for more extensive trials. At Kakamega all the clones have remained clear of mosaic and brown streak symptoms. Under these circumstances the number to be retained could be drastically reduced on the basis of habit, yield and palatability. Unfortunately,

on this station predial larceny, in spite of all reasonable precautions, has so far precluded any appraisal of probable yield as a basis for primary selection.

146. When this material can be freely issued for trial, varieties suited to most up-country requirements should be available; but so far little is known of the general or particular regional adaptability of these clones. This side of the work is outside the scope of E.A.A.F.R.O.

147. It has now been decided that further breeding is unlikely to offer any substantial advance; and the E.A.A.F.R.O. contribution to this project will be gradually closed during 1959 and 1960. The following plans will be put into operation:—

(*a*) A basic collection of material will be maintained indefinitely under direct control of E.A.A.F.R.O., in case any further breeding is undertaken in the future.

(*b*) Material of interest to the coastal region, up to and including the 54-series of clones, will be maintained at Amani and issued from there for field trials as required, up to the end of 1959; thereafter the stock of this material will be discarded.

(*c*) Selections from the 55- and 56-series of clones, resulting from the trials concluded in 1958, will be established in Amani maintenance plots and will be available for distribution during the period 1959-60. Any material that may show outstanding merit during test from this stock will then be available to an up-country station or stations through quarantine at Muguga.

(*d*) In December, 1960, E.A.A.F.R.O. staff will be withdrawn from Amani.

148. Under this scheme all the Departments of Agriculture will have ample time to get and propagate any material they may require and to establish maintenance plots for their own use and further selection.

(2) *The Year's Work*

L. R. Doughty and D. W. Gourlay

149. The work carried out this year has been the field testing of the last of the hybrid seedlings of the 54-, 55- and 56-series of crosses. These were included in five trials at the Sisal Experimental

Station, Ngomeni, T.T. Planting conditions during the short rains, 1957, were favourable, but during the season mosaic was relatively light and brown streak also not severe. At harvest the symptoms of brown streak were present as small necrotic areas in a high proportion of roots but were rarely extensive. In one of these trials the control varieties were duplicated, planting material being cut from the previous trials at Ngomeni for one series; the other followed the normal routine, cuttings being taken from the clean maintenance plots at Amani. Of the three control varieties, 37244E showed rather more mosaic in the plots grown from cuttings from the previous years' trials. Stocks of 4763/16 showed about the same degree of mosaic infection and 5318/34 was free from mosaic irrespective of source of origin.

150. Yields were all poor; but 15 clones have been retained for issue for further trial, as soon as stocks can be produced from the maintenance plots. Two clones are intercrosses between lines of ceara and *dichotoma* origin and 11 from intercrosses of ceara and *melanobasis* derivatives. Thirteen of these clones went through the trials with no symptoms of mosaic; the other two showed slight mosaic symptoms but were free from brown streak symptoms and gave good yields in comparison with the others in the trial. In all, five clones were free from brown streak symptoms, three of these being also free from mosaic.

151. Five of these clones are already included in a long-term trial being conducted by the Kenya Department of Agriculture at Matuga, Mombasa. The retentions are:—

54140/10	5538/117*	5621/10
54185/11*	5539/33*	5642/14
54302/125*	5543/156	5648/33
5535/17	5547/24	5648/50
5538/19*	5620/9	5649/17

(Those marked * are also in the trial at Mutuga)

152. A long-term trial, planted in the short rains of 1956, was harvested in June, 1958. The 25 entries in this trial included those clones of the 53- and 54-series that had shown most promise in their short-term trials. The five issues of the 53-series were included once more for a second long-term trial. The control varieties were the two most successful coast issues, 4763/16 and 46106/27.

153. The incidence of mosaic in these control varieties was much higher in this long-term trial than in the previous one. Brown streak infection was, however, at approximately the same level as in the earlier trial. Of the five most recent issues, 5315/39 suffered severely from brown streak, and 5317/21 showed a lower level of resistance to mosaic and a much decreased yield. Although these two clones are still on trial in the coastal region, the last mentioned has been discarded from the Amani maintenance plots so that only 5315/39, 5318/34, the best all-round clone to date, 5342/1 and 53121/22 are now available from this issue. The other 16 new clones in the trial were discarded from the Amani plots as they are not suited to the coastal region, but four of these are available at the Agricultural Department Farm at Kakamega (see below) and 13 from Ukiriguru, P.O. Fela, T.T.

154. On a recent safari to cassava experimental areas in the coastal belt and the immediate hinterland of T.T., Gourlay reported the present position as follows. In the Tanga Province 46106/27 and 4763/16 are being multiplied and issued as fast as possible. The proportion of plants showing mosaic symptoms rarely exceeds 10 per cent, and yields are better than local material and the flavour popular. Around Handeni, in the same Province, none have been issued, but 4697/4 is being multiplied ready for issue as is 46110/8, but this last clone is apparently less resistant under local conditions than the first and may be discarded. In neither area have the five newer issues (see preceding paragraph) been released. So far as observations go, all five appear to be more resistant to mosaic than earlier issues. Theft of root and planting material has so far precluded any accurate assessment of their potentialities in the field.

155. The picture seems to be the same in the Morogoro district of the Eastern Province and at Chambezi on the coast. At Chambezi, 5315/39 has, however, been discarded for bitterness, leaving the following clones still under trial

46106/27	5317/2	5318/34
4763/16	5317/9	5342/1
50676/9	5317/21	53121/22

and of these 5318/34 appears to have consistently higher resistance to mosaic than all others.

156. In Zanzibar the two clones 4697/4, with rather bitter roots, and 46106/27 have been distributed to some extent; and an early issue, T206, has been revived for use on Kinongo soils.

The five recent issues have gone into a second trial as the first trial was carried out in a poor season and there was therefore little to choose between them. In conclusion of his report Gourlay states "To sum up: in the districts I have visited, in spite of the fact that nothing is done in the way of selection of planting material or in length of growing period, to make the most of the advantages of the Amani clones, I have seen or heard nothing to indicate that selection on the basis of our results at Mlingano is not, in general, applicable also to these areas. The fact that, in the areas where mosaic is most severe, none of them remains clean does not mean that they are failures, for their symptoms appear to be less severe than those of more susceptible varieties, and they are able to produce more clean growth when conditions are favourable. In spite of mosaic, yields also appear to be well maintained."

157. In the coastal belt the emphasis is normally on short-term cassava. In fact in some areas we are informed that cassava root on plants more than one year old is not eaten. Most of the resistant cassavas are long term and, although they have held their own quite well on a short-term basis compared with local types, they have much greater potentialities if they can be grown for 20 months. In fact the extra eight months usually more than doubles the yield with no deterioration in quality. It appears, therefore, that the new material, in the coastal belt, is not being exploited to its full capacity.

158. Ninety-one clones were established at Kakamega on the Agricultural Department's Experimental Farm in May, 1956. Neither mosaic nor brown streak appeared in any of this material and bigger plots were established from the original cuttings in July, 1957. After a further year of disease-free growth, half the plants in each plot were dug in July, 1958, and 25 clones selected for inclusion in a yield trial which is to be planted as soon as feasible. At our request the Agricultural Officer (Research) has agreed to retain the full collection for a further year, so that the material can be available if required for tests in other parts of the province.

159. In the different environment it is not surprising that the provisional selections are not the same as in the coastal belt. We obviously have here a collection of clones that should be able to meet all up-country needs if they can be tried out in a number of different cassava-growing districts. Here again, however, yield trials are severely hindered by theft.

160. A still more extensive collection has been established at Ukiriguru, in the Lake Province T.T., where it was to be managed by D. L. Jennings. Since his departure, however, it has proved difficult to make satisfactory arrangements for carrying on the work owing to the many other commitments of the officers on the Station.

MAIZE BREEDING

L. R. Doughty and T. Graham

161. During the past few years we have been investigating the possibility of producing balanced heterotic populations of maize on the lines outlined by Brieger (1950). In 1957 we inter-crossed our selected inbred lines and mixed the seed from the various parental lines mechanically to produce six basic groups. These groups have been planted this season for a preliminary assessment of their value in comparison with the bulk material from which these lines have been bred, and also for comparison with other local types, in a series of trials at different centres, in co-operation with the Plant Breeder of the Kenya Department of Agriculture at Kitale.

162. The season has not proved to be a very good one as there was some delay in the onset of the rains and several long dry spells during the early growing season. From the middle of July an adequate rainfall enabled long-term maize to make up to a great extent for the early checks, but crops are likely to be light, and the value of experimental results considerably diminished.

163. Only two experiments have been harvested to date and for these only the preliminary data are available. The Co-operative Ecological trial at Kakamega was cut and stooked on 9th October and the cobs harvested on the 17th. A feature of this experiment was the very high proportion of damaged and also diseased cobs. In the first category there was a considerable amount of termite damage and sprouted grain, contributed to by the heavy wind, hail and rain storms experienced. These, however, are quite normal hazards in this region. The same causes may have contributed to the proportion of cobs with fungal rots. The overall proportion of damaged cobs was 15 per cent and of diseased cobs 16.7 per cent. On the basis of the crude cob yields, the only data available at present, it appears that only three varieties will have given yields significantly exceeding the mean of the experiment. One of these is the Kakamega farm seed and the others from Kitale,

one being the Kitale Synthetic. Our first two choices of Brieger synthetics, however, come in the upper half of the yield table.

164. The second experiment is a top cross trial of Katumbili derivatives. There were 49 entries in this trial of rather earlier maturing maize, and yields were low. A preliminary inspection of the cob data indicates that there will be no significant varietal differences.

165. A new synthetic stock, BSN 17, to produce which all inbred remnant seed was planted has, in the end, produced some seed. This material had a very hard time and was only saved by hand watering in the early stages.

166. Remnant inbred seed of the components of our synthetics has been handed over to the Plant Breeder, Kitale. Where no remnant seed was available, top cross seed from the 1958 crop has been passed on.

167. During the past season we have had the opportunity of studying the behaviour of our bulk maize on a site heavily manured with F.Y.M. in comparison with maize, on another part of the same field not so manured. It is estimated that the manured section received 15 to 20 tons of manure per acre. The maize was planted by machine and both areas received double super phosphate at about 90 lb. per acre.

168. Planted in mid-March immediately after a fall of 1½ inches of rain, germination was good but subsequent lengthy dry periods took a considerable toll of plants; there were, however, far fewer casualties on the manured blocks. The manured plants were also much more vigorous and bigger in all respects than those receiving phosphate only, the mean height of the top cob, above ground level, was 15 dcm. on the manured area compared with 12.3 dcm. on the unmanured. The mean weight of the sound cobs from the manured area was 9.4 oz., compared with 7.9 oz., and the yields of cobs were at the rate of 4,969 lb. per acre on the manured and 2,337 lb. per acre on the unmanured, the surviving populations being 7.8 and 5.7 thousand per acre respectively. Eleven per cent of the good cobs had been stolen from the manured plots at harvest compared with 1.5 per cent from the other area, so that the potential yield difference is greater than shown. We have not yet got the crib dried weights and grain weights, but the cob yields quoted above give a reasonable indication of the increases in yield that can be obtained from improved standards of cultivation.

169. *Acknowledgments.* We have gratefully to acknowledge the help and co-operation of the officers of the Departments of Agriculture in our experimental work and in particular those at Kakamega, Matuga and Tanga, and the Plant Breeder, Kitale.

THE GENETICS OF RESISTANCE IN MAIZE TO THE VIRUS OF STREAK DISEASE

H. H. Storey and A. K. Howland

170. The basis of this work was set out in our Report for 1957. Progress was at first delayed by unexpected difficulties in breeding stocks of the leafhopper vector, *Cicadulina mbila* (Naude), which are essential for the testing technique. Difficulties were overcome during 1958 and tests were completed on a wide range of maize material.

171. Our initial plan had been to isolate resistant maize lines from the seed supplied by Mr. Doughty from his Eldoret breeding plots. These had originated, as explained in our 1957 Report, in pre-war Amani stocks; but Mr. Doughty had maintained them only with great difficulty and out-crossing had occurred at one stage or another. Consequently few resistant plants appeared in our glass-house tests, and we appeared to be faced with a long programme of selection and inbreeding.

172. Fortunately, we were able to obtain through the courtesy of Dr. G. J. M. A. Gorter, of the Union Department of Agriculture, Pretoria, seed of a number of his resistant lines, including inbreds from the variety Peruvian Yellow and from earlier crosses of Peruvian Yellow by Hickory King. Several of these, by our glass-house testing method, proved to be highly resistant and nearly pure breeding. Furthermore these Pretoria lines are much more vigorous than the Eldoret ones, in which deleterious genes seem to have accumulated. This material, for which we are grateful to Dr. Gorter, gives us a much better start for our genetical studies.

173. At the time of writing this report, we have a large number of plants nearing maturity, from selfings of selected resistant plants and crossing these with susceptibles. The testing procedure is now working smoothly, and we expect in forthcoming months to make progress comparable in speed with that found possible in studies of rust resistance.

174. It is too early yet to obtain any picture of the genetical situation; but it appears scarcely probable that we shall find single-

factor control of resistance to streak as was true of rust resistance. We have, however, ample evidence that resistance factors exist; and the difference between resistant and susceptible plants is most striking.

THE AMERICAN RUST DISEASE OF MAIZE CAUSED BY *PUCCINIA POLYSORA* UNDERW.

H. H. Storey and A. K. Howland

175. Work on this problem has been restricted to maintenance of rust races in the Muguga glasshouses, and the breeding of a further small series of pure lines of maize resistant to one or other of the rust races at present known. The purpose has been to ensure that, in the event of new rust races appearing in the field, we shall be in a position to resume genetical studies, if these seem desirable.

176. Up to the present no evidence has appeared suggesting that any race other than the original "EA.1" has become established at any testing site. In particular it is satisfactory to learn from research officers at Nachingwea, where bulk quantities of rust-resistant "Katumbili" maize have been bred, that no sign of any breakdown in resistance has been observed, although for other reasons during the past season yields from this material have been disappointing.

177. Papers describing this work have been published as follows: a genetical report published in *Heredity*, which was summarized in the E.A.A.F.R.O. Report for 1957, and a report on practical breeding in the *Empire Journal of Experimental Agriculture* (Vol. XXVI, No. 101, pp. 1-17), in the authorship of which we collaborated with the plant breeders of Tanganyika, Kenya and Uganda. A second genetical paper, on studies of the relation between the two genes found to confer resistance in maize, was completed during 1958 and was accepted for publication in *Heredity*.

SORGHUM BREEDING RESEARCH SCHEME

H. Doggett

178. Mr. Doggett was at Muguga from 4th January to 19th August, when he was transferred to Serere. During his stay at Muguga, he worked in the Plant Pathology Section, and received much assistance from Dr. Storey, Dr. Sheffield and Mrs. Howland.

179. The climate at Muguga is unsuitable for sorghum, but it proved possible to grow some tetraploid sorghum varieties and crosses in the greenhouse, and to make a few fresh autotetraploids.

180. A mutant plant with very small spikelets arose at Ukiriguru in 1957. Only 15 seeds were set, and these were grown at Muguga. All plants had normal spikelets, so it seems that the 15 seeds set were outcrosses. Presumably the male organs of the mutant are defective.

181. A study was made of the colchicine technique, which had been used for sorghum. A standardized treatment is required, which will yield a high proportion of autotetraploid plants consistently. Maize was used, as it grows at Muguga, and is a difficult plant in which to induce polyploidy with colchicine. A technique which works with maize is likely to be even more effective with sorghum. Two colchicine concentrations, two times of treatment, and four treatment temperatures were used, with at least three replications of each treatment. Tetraploids were identified from pollen size, those containing a proportion of large grains (diameter about 20 per cent greater than the diploid) were treated as affected by the colchicine. Mrs. Howland gave much help with the pollen measurements. Root tip squashes were made from a sample of plants to check the pollen observations. Colchicine induced tetraploids in maize are very often sectorial, and progeny may be diploid. In a tillering grass such as sorghum, a tetraploid tiller can usually be obtained from a sectorial plant and tetraploid progeny assured.

182. The greatest source of loss in treated seedlings is due to mould damage while the plants are recovering from the effect of the colchicine. This was minimized by the use of surface sterilized seed germinated in distilled water, by boiling the colchicine solution before use, and by watering the recovering plants with distilled or boiled water. Sterile soil for recovery did not seem essential, trials with sterile sand proving no better than ordinary soil watered with distilled water.

183. Seed was germinated at 25° C. for five or six days. The coleoptile was cut under water about 1 cm. above the first node and immersed in the colchicine solution. The roots did not come in contact with the solution, but were kept damp under a pneumatic trough.

184. The pollen grain measurements have not yet been completed, but the following results have been obtained so far:—

PLANTS WITH LARGE POLLEN GRAINS AS A PERCENTAGE OF SEEDLINGS ORIGINALLY TREATED

A. *Concentration and time of treatment*

Colchicine concentration	0·2%	0·4%	Mean
Time of treatment: 3 hrs. ..	53	33	43
6 hrs. ..	40	27	33
Mean	47	30	38

There were 60 seedlings in each treatment.

B. *Temperature of treatment*

	25°C	35°C	40°C
Percentage polyploid	50·5	45·0	33·0
Seedlings treated	40	40	160

185. A mean of 38 per cent of plants with tetraploid sectors, or wholly tetraploid, is very satisfactory. Time was spent on improving cytological technique, and in reading up the sorghum literature.

186. At Serere, the season was too far advanced for sorghum planting on a field scale, but some plants of the F_5 generation of $4N \times 5$ were grown in the nursery for observations of meiosis and seed set.

187. Studies were also begun of the effect of *Celosia argentea* on *Striga* seed germination. Mr. Stephens drew my attention to the fact that this plant is never weeded out of fields, and is alleged to "kill" *striga*. It appears to be planted deliberately in the sorghum and eleusine crops to reduce *striga*, the same tradition being found throughout the district. A custom of this kind is worth a little attention.

STEM-PITTING CONDITION IN COFFEE

F. M. L. Sheffield

188. Late in 1956 the foliage of many young *arabica* coffee trees at Lyamungu became thin and chlorotic. This was especially noticeable in trees which had borne heavy crops and some of the affected trees died. Dr. E. A. Riley, Pathologist in the Tanganyika Department of Agriculture, noticed that some of the trees were swollen to a bottle shape at the bases. When bark was peeled from this region, grooves or pits could be seen on the exterior of the xylem cylinder corresponding with ridges or pegs inside the peeled phloem, a symptom very similar to that caused by some viruses affecting *Citrus* spp. Dr. Riley was unable to isolate any causative organism from affected trees and sought the help of E.A.A.F.R.O. in the solution of the problem.

189. At this time the condition was thought to be confined to trees grown from seed originating from Lyamungu and planted later than 1953. Many plantations have now been visited and the condition is known to affect both seedling and clonal material of many varieties of *arabica* coffee of differing origin. It is widespread, occurring in both African and European plantings, on many soil types and in widely separated areas of Tanganyika and Kenya at altitudes varying from 4,000-6,500 feet. It occurs under heavy shade and when completely unshaded and with and without irrigation. Only some affected trees have yellow leaves and a very small proportion are known to have died: others look healthy and bear well. It now seems unlikely that chlorosis of the leaves is due to the condition, but it is possible that a combination of the stem-pitting condition with the cause of chlorosis (e.g. overbearing) may result in death.

190. The stem-pitting symptom is usually confined to the lowest 18 inches of the trunk but has occasionally been found on branches as much as 3 feet from the ground.

191. Sections through the trunks of normal trees show a clearly defined wood cylinder surrounding a small central pith and traversed by medullary rays, one/two cells wide. The cambial cells are usually rectangular in section. Medullary rays may be linked by thin-walled cells crossing the wood tangentially.

192. Sections through affected stems show considerable disorganization of the xylem which is fluted in outline. The

cambial cells are distorted and consequently the xylem and medullary ray cells developing from them are irregular. Large irregular masses of thin-walled misshapen cells are included amongst normal fibres and vessels. The phloem is irregular in outline but the cells composing it appear quite normal. The disorganization is seen near the centre of the stem and must obviously have started very early in the life of the plant. The external symptoms vary in intensity. They may be confined solely to disorganization of the xylem: this may result in grooving to the exterior of the xylem cylinder and may be accompanied by furrowing of the bark and swelling of the trunk.

193. The condition has now been found in trees planted up to seven years ago and occasionally in older ones. There is some suggestion that it may occur in the younger trees and be concealed as they increase in girth. If this is so, it may have occurred in East Africa for many years.

194. Various possible causes of the condition have been considered. The wide distribution over a considerable range of environmental conditions shows that is unlikely to be due to physiological causes or to any soil deficiency or toxicity. The toxic effect of insecticidal or other chemical treatments is not a possible cause as the condition is prevalent where no such measures have been used. The direct effect of insect attack cannot be entirely eliminated: cambium miners and capsids are known to cause somewhat similar effects in certain other hosts. Microscopic examination has so far failed to reveal any possible pathogen, thus confirming Riley's failure to isolate one from affected tissues.

195. Grafting experiments are now in progress in the glasshouses to test the possibility of a virus being the cause. A similar disorganization of the tissues may be seen where the main stems are "capped": experiments are in progress in the glasshouses to find out whether the condition can be induced by mechanical damage.

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RATOON STUNTING DISEASE OF SUGAR CANE

F. M. L. Sheffield

196. Although ratoon stunting disease is thought to be widespread throughout all the cane-growing countries of the world, no satisfactory diagnostic character is known. Several symptoms or chemical reactions described in the literature have been tested here but none seems reliable in all varieties under all conditions.

197. The character most often used in diagnosis is a red discoloration, caused by blocking of the xylem vessels and visible to the naked eye as red dots and "commas" in longitudinal sections of nodes towards the bases of mature canes. This, combined with a complete absence of other symptoms, is regarded as diagnostic of ratoon stunting disease, but absence of the symptom does not prove the cane to be free of the virus (Hughes and Steindle, 1955).

198. When varieties newly released from closed quarantine at Muguga are sent to open quarantine at Kawanda, heat therapy is applied as a routine measure to the setts before planting. In 1957, much red discoloration was found in the stems of the crop resulting from these treated setts. To test whether the treatments had broken down, 40 two-bud setts of each of two affected varieties, PR 1000 and H38/4443, were sent to Muguga. Twenty setts of each variety were again given treatment known to be more than adequate to inactivate the virus. All setts were germinated under glass. Ten treated and ten control setts of each variety were then planted in the grounds of the Scott Agricultural Laboratories and the remainder at Muguga. After a year, canes were cut and examined. When split longitudinally all showed red dots scattered in both nodes and internodes. PR 1000 was more severely affected than was H38/4443 but no differences were obvious between the once and twice heat-treated cane. Many of the discoloured areas in the tissues were quite unlike those due to ratoon stunting disease. Their cause is unknown but their presence prevented the use of this character in the diagnosis of ratoon stunting disease.

199. A pink discoloration visible in the nodes when cane is split longitudinally is the only diagnostic character of the disease yet described in young cane (Hughes and Steindl, 1955). This may be useful where diseased and healthy canes of certain varieties are growing in identical conditions. When immature canes have been examined in the field in East Africa, pink nodes have sometimes been found in healthy cane, orange coloured nodes in infected

cane, and no consistency could be found in diseased or healthy canes of any one variety.

200. A chemical test described by Farrer (1957) as infallible consists in the immersion of sections from mature nodes in 3 per cent hydrogen peroxide for 10-15 seconds followed by treatment for 20-30 seconds in concentrated hydrochloric acid. A green colour is said to develop around the vascular bundles in healthy but not in infected plants. I failed to obtain this reaction with sections from healthy cane of H38/4443.

201. A further chemical test involving treatment of sections taken from the lower nodes of mature cane with 0.5 per cent tetrazolium salt at 35° C. in the dark has been described by Antoine (1957). A red colour develops more rapidly in infected than in healthy tissues. This technique has not been fully tested, as strictly comparable diseased and healthy material of a single variety was not available. The method was not valid when materials of one age but of different varieties were available for comparison nor when materials of one variety but different ages were available.

202. None of these methods is satisfactory to the experimentalist who wants a rapid diagnostic method applicable to cane of all ages nor to the agriculturist who is unlikely to have known healthy cane strictly comparable in every way with that which he suspects of being infected. A different approach has therefore been adopted in some attempts to find a reasonably quick method of diagnosis.

203. Sections of cane stems have been examined microscopically in the hope of finding some anatomical abnormality visible earlier than the filling of the xylem vessels with the red coloured deposit mentioned under paragraph 197 above. Certain graminaceous plants are known to be symptomless carriers of the virus. Some of these have been similarly examined, so far without success.

204. A number of the usual virus test plants and also a series of monocotyledonous plants are being inoculated in the hope that one will show either external symptoms or anatomical abnormalities.

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PLANT NEMATOLOGY

A. G. Whitehead

(formerly Colonial Research Fellow attached to E.A.A.F.R.O., now Nematologist, E.A.A.F.R.O.)

205. In the year under review the Nematologist completed his survey of the plant parasitic nematodes of East Africa with visits to the Southern and Lake Provinces of Tanganyika; the Mengo, Lango, Teso, Mbale and Busoga Districts of Uganda; the Meru, Embu, Nyeri, Fort Hall and Sotik Districts of Kenya, and the Zanzibar Protectorate. An extensive final report of the survey will be made to the Colonial Office on the completion of these studies in the United Kingdom.

206. Six hundred soil-nematode population analyses have been completed in connexion with the survey. The results are now being analysed and will be written up in due course, to provide a basis for future studies in tropical plant nematology.

207. At least 25 genera of known and suspected plant parasitic nematodes are now known to occur in East Africa. In addition to those listed in the last annual report five more genera have been found. Of these, *Gottholdsteineria* Andrássy, 1958, and *Scutellonema* Andrássy, 1958, are known, which were previously listed as species of *Rotylenchus* Filipjev, 1934. The three remaining genera belong to two new subfamilies of Tylenchidae Thorne, 1949, i.e. Rotylenchoidinae n.subfam. (type genus: *Rotylenchoides* n.g.) and Trichotylenchinae n.subfam. (type genus: *Trichotylenchus* n.g.; also included is *Belonolaimus* Steiner, 1945). Description of these two new subfamilies have been submitted for publication. Three genera *Heterodera* Schmidt, 1871, *Radopholus* Thorne, 1949, and *Dolichodorus* Cobb, while of considerable economic importance in temperate and other tropical regions, have been found in no cultivated, grassland or indigenous forest soil and are therefore assumed to be foreign to East Africa.

208. A line sample, comprising 150 soil and root samples, collected at 20-mile intervals over 5,000 miles, of the wayside grasses of East Africa has been made and is now being analysed. The results indicate the very widespread distribution of many plant parasitic nematodes.

209. Studies of the tylenchid faunae of patches of indigenous forest throughout East Africa have been made. Nearly all the genera found in cultivated soils are also present in indigenous forest soils. *Meloidogyne* spp. are present in indigenous forest soils and may be of importance in future plantings of perennial crops in catchment areas.

210. A sampling experiment has been carried out on a badly diseased pyrethrum planting near Limuru, Kenya, with a view to assessing nematode population changes in the course of a year's observations, the extent of nematode damage and the intra-field variability of the soil-nematode complex. This work is now largely completed and is being written up.

211. Detailed taxonomic studies of the principal plant-parasitic genera of East African soils are in progress. Such work is of fundamental importance to the future control of plant nematoses in East Africa. Although it is far too early to give details of each genus, the distributions of *Meloidogyne* spp. are now known in outline. *M. "javanica"* is the commonest species in East Africa. In Eastern and Central Uganda *M. "incognita"* and *M. "incognita var. acrita"* are together as common as *M. "javanica"*. In Kenya *M. hapla* is very common in pyrethrum but *M. "incognita"* and its variants are uncommon. Several new species of *Meloidogyne* Goeldi are now known in East Africa, for the most part in the higher altitude areas and especially in indigenous forests.

212. A detailed list of the principal nematode attacks found in the course of the two-year survey is given below, but certain instances found in the course of the past year are worthy of special mention.

213. *Coconut Palm.* Infection of the trunk of coconut palms by *Aphelenchoides* spp. associated with reddening of the surrounding ground tissue have been found in two cases of declining palms and may be more widespread.

214. *Coffee, arabica.* Sixty per cent of the coffee nurseries in the Meru district of Kenya contain attacks of the root-knot nematode *Meloidogyne africana* n.sp. (in press). Heavily attacked seedlings are seriously affected, the plants are stunted and chlorotic. This nematode has now been found in widely isolated indigenous forest areas and may, as indicated above, constitute a problem for future development of crops in such areas.

215. *Cotton. Root-knot nematodes* (*Meloidogyne* spp.) and/or spiral nematodes (*Scutellonema* spp.) have been found in large numbers in samples of soil from around the roots of cotton, affected by the wilt fungus *Fusarium vasinfectum Atk.* (syn. *F. oxysporum f. vasinfectum* (Atk.) Snyder and Hansen) in the Lake Province, Tanganyika, and Busoga District, Uganda. These nematodes may affect the expression of the disease. In a similar way bananas may be rendered more susceptible to "panama" disease if heavily attacked by nematodes. The inter-relationships of nematodes with bacterial and fungal diseases are worthy of closer study in East Africa.

216. *Sugar Cane.* Analysis of soil samples from around the roots of sugar cane in the Lugazi and other parts of Uganda and on the Kenya Coast has exposed high populations of several parasitic genera of which *Helicotylenchus* Steiner, *Pratylenchus* Filipjev and *Meloidogyne* Goeldi are of principal importance. As claimed in Natal *Meloidogyne* and perhaps *Helicotylenchus* and *Pratylenchus* may reduce yields appreciably.

217. *Tobacco.* Tobacco is now known to be attacked by *Meloidogyne* spp. whenever it is grown on a commercial scale in East Africa. Heavy nematode attacks are associated with considerable yield losses through stunting and chlorosis of affected plants.

THE PRINCIPAL NEMATODE ATTACKS FOUND IN EAST AFRICAN CROPS

Crop	Common Name	Nematode genus attacking	Known occurence
Acacia mollisima.	Black Wattle.	*Meloidogyne.*	Widespread in Kenya.
Ananas sativus.	Pineapple.	*Meloidogyne.*	Widespread in Kenya.
		Rotylenchulus.	Localized.
		Helicotylenchus.	Localized.
Camellia senensis.	Tea.	*Meloidogyne.*	Widespread in East Africa.
Carica papaya.	Pawpaw.	*Meloidogyne.*	Widespread in East Africa.
		Rotylenchulus.	Localized in East Africa.
		Scutellonema.	Localized in East Africa.
		Hemicycliophora	Localized in East Africa.
Chrysanthemum cinerariaefolium.	Pyrethrum.	*Meloidogyne.*	Widespread in Kenya and Tanganyika.
		Pratylenchus.	Localized in Kenya.
		Aphelenchoides rizema-bosi.	Localized in Kenya and Tanganyika.
Citysus prolifera.	A tree legume.	*Meloidogyne.*	Ol Joro Orok, Kenya.
Clovers various.		*Meloidogyne.*	Kenya.
Cocos nucifera.	Coconut.	*Meloidogyne.*	Localized, Zanzibar.
		Rotylenchulus.	Localized, Zanzibar and Kenya.
		Aphelenchoides.	Zanzibar.

Crop	Common Name	Nematode genus attacking	Known occurence
Coffea arabica.	Arabica coffee.	*Meloidogyne spp.*	Widespread in mountain areas of East Africa.
		Helicotylenchus.	Localized, Tanganyika.
Dianthus caryophyllus.	Carnation.	*Meloidogyne.*	Widespread in Kenya.
		Rotylenchulus.	Localized in Kenya.
		Scutellonema.	Localized in Kenya.
Eleusine coracana.	Finger millet.	*Meloidogyne.*	Localized in Uganda.
		Scutellonema.	Widespread in Uganda.
		Pratylenchus.	Localized in Uganda.
Glycine soja.	Soya bean.	*Meloidogyne.*	Uganda.
Gossypium hirsutum.	Upland cotton.	*Meloidogyne.*	Uganda and Lake Province, Tanganyika.
		Scutellonema.	Localized, Tanganyika.
		Pratylenchus.	Localized, Tanganyika.
Hibiscus cannabinus	Indian hemp.	*Meloidogyne.*	Mwea/Tebere, Kenya.
Hibiscus sp.		*Meloidogyne.*	Uganda.
Indigofera subulata.		*Meloidogyne.*	Localized, Uganda.
Lactuca sativa.	Lettuce.	*Meloidogyne.*	Widespread in East Africa.
		Tylenchorhynchus	Localized, Tanganyika.
		Scutellonema.	Localized, Tanganyika.
Legumes various.		*Meloidogyne.*	Serere, Uganda.
Lycopersicon esculentum.	Tomato.	*Meloidogyne.*	Widespread in East Africa.
		Rotylenchulus.	Localized in East Africa
		Helicotylenchus.	Localized in East Africa.
Medicago sativa.	Lucerne.	*Ditylenchus dipsaci.*	Naivasha, Kenya.
Musa cavendishii.	Chinese dwarf banana.	*Meloidogyne.*	Common, Kenya.
		Pratylenchus.	Widespread, Kenya.
Musa ensete.	Washingtonia.	*Meloidogyne.*	Turbo, Kenya.
		Scutellonema.	Turbo, Kenya.
Musa paradisiaca sapientum.	Various.	*Meloidogyne.*	Common in East Africa.
		Helicotylenchus.	Localized in East Africa.
		Pratylenchus.	Widespread in East Africa.
		Hoplolaimus.	Localized in East Africa.
		Rotylenchulus.	Localized in East Africa.
Narcissus pseudo-narcissus.	Daffodil.	*Ditylenchus dipsaci.*	S. Kinangop, Kenya.
Nicotiana rustica.	Nicotine tobacco.	*Meloidogyne.*	Ankole, Uganda.
Nicotiana tabacum.		*Meloidogyne.*	Widespread in East Africa.
		Scutellonema.	Localized in East Africa.
		Pratylenchus.	Rare in East Africa.
		Tylenchorlynchus.	Rare in East Africa.
Passiflora edulis.	Passion fruit.	*Meloidogyne.*	Widespread in Kenya and Tanganyika.
		Helicotylenchus.	Localized in Kenya and Tanganyika.
		Rotylenchoides.	Localized in Tanganyika.
Pastinaca sativa.	Parsnip.	*Meloidogyne.*	Widespread in East Africa.
Phaseolus vulgaris.	Dwarf bean.	*Meloidogyne.*	Widespread in East Africa.
		Scutellonema.	Common in East Africa.
		Pratylenchus.	Common in East Africa.
		Tylenchorhynchus.	Rare in East Africa.
		Helicotylenchus.	Common in East Africa.
Piper nigrum.	Pepper.	*Meloidogyne.*	Zanzibar and Uganda.
Pinus radiata.	Pine.	*Helicotylenchus.*	Kenya in plantation.
Pisum sativum.	Field pea.	*Meloidogyne.*	Widespread in East Africa.

Crop	Common Name	Nematode genus attacking	Known occurence
Saccharum officinarum.	Sugar cane.	*Meloidogyne.*	Common in East Africa.
		Scutellonema.	Widespread in East Africa.
		Pratylenchus.	Localized in East Africa.
		Rotylenchulus.	Localized in East Africa.
		Helicotylenchus.	Widespread in East Africa.
		Hemicycliophora	Localized in East Africa.
Solanum tuberosum.	Irish potato.	*Meloidogyne.*	Common in East Africa.
		Rotylenchulus.	Localized in East Africa.
Symphytum peregrinum.	Russian Comfrey.	*Meloidogyne.*	Localized in East Africa.
		Scutellonema.	Common in East Africa.
		Rotylenchulus.	Localized in East Africa.
		Pratylenchus.	Localized in East Africa.
		Paratylenchus.	Widespread in East Africa.
Syzygium aromaticum.	Clove.	*Tylenchus.*	Widespread low populations, Zanzibar and Pemba.
Theobroma cacao.	Cocoa.	*Meloidogyne.*	Zanzibar.
Vicia faba.	Broad bean.	*Meloidogyne.*	Widespread in East Africa.
		Paratylenchus.	Thomson's Falls, Kenya.
Vigna sp.	Cowpea.	*Meloidogyne.*	Widespread in East Africa.
Zea mays.	Maize.	*Meloidogyne.*	Rare in Tanganyika.
		Scutellonema.	Common in East Africa.
		Pratylenchus.	Very localized in East Africa.

PROTECTION OF EAST AFRICA FROM INTRODUCED PESTS AND DISEASES

(1) *The Organization of Plant Import Control*

H. H. Storey

218. East Africa was one of the earlier countries in Africa to recognize the dangers to its agriculture resulting from the uncontrolled introduction of plants from overseas, and to take co-ordinated action to limit these dangers. In 1934 a conference held at Amani under the auspices of the Conference of Governors of British East African Territories agreed on a set of rules for controlling the import of plants thought to be dangerous; and its recommendations formed the basis for legislation adopted by the three mainland territories.

219. Some 20 years later it was felt generally that a revision was necessary in the light of new knowledge. A second conference was called by the High Commission in May, 1956, at Muguga, and from this emerged a Standing Technical Committee for Plant Import and Export, with membership from the three mainland territories, from Zanzibar and from E.A.A.F.R.O. I was appointed Chairman, Dr. F. M. L. Sheffield as E.A.A.F.R.O. member, and Mr. P. J. Dickinson (of the Plant Quarantine Station at Muguga)

Secretary. Since then three meetings of the full Committee have been held, and four of its executive Subcommittee on which all the Muguga members serve. It was necessary to consider each type of plant likely to be imported and to advise on the measures of control desirable in the light of our knowledge of its pests and diseases. The Committee was greatly indebted to one of its members, Dr. R. H. Le Pelley of the Kenya Department, who over many years had accumulated a large store of information on plant import problems. Recommendations were incorporated in a card index, copies of which were distributed to all officers in East African territories who might be concerned in the issue of plant import permits or in the inspection of imported material. As new knowledge calls for changes in procedure, new cards are issued from E.A.A.F.R.O. to all holders of the Index. Planning for these meetings and action on their decisions called for much work by the E.A.A.F.R.O. staff concerned.

220. During 1958 this work, and the consequent deflection of effort from research, increased, as a consequence of the ratification by the British Government of an Inter-African Phytosanitary Convention. The East African Governments relied on their Standing Technical Committee to watch their interests in relation to this Convention and to collaborate with the Secretary of the Commission established under the Convention. Dr. J. Risbec had in fact visited Nairobi in March, 1957, and had incorporated in his recommendations many of the procedures adopted by East Africa.

221. A meeting of the Commission in 1957 in London had recommended the calling of a meeting of specialists to examine detailed policy for each category of imported plants. By invitation of the E.A. High Commission, this meeting took place in April, 1958, in Nairobi, and I was called upon to take the chair. Twenty-one delegates and observers from seven countries attended. Dr. Sheffield and Mr. Dickinson serving as members of the United Kingdom delegation. Its report was considered by a meeting of the Commission in September, 1958, when its recommendations were largely ratified, with a few modifications and additions.

222. These meetings, and negotiations concerning them, have placed a very considerable burden on the staff of the Plant Pathology Section, and particularly on Dr. Sheffield, during my absence in Europe during July and August. There still remains much to be done to incorporate the Commission's decisions into East African procedures; very few major changes will be necessary

but a number of minor alterations will necessitate a completely new issue of the Card Index previously mentioned. After that it is to be hoped that a period of reasonable stability will follow, with less calls on the time of E.A.A.F.R.O. staff and on that of the members of the East African Standing Technical Committee.

(2) *Quarantine of Imported Plants*

F. M. L. Sheffield

223. A further activity of the Pathology Department, resultant on E.A.A.F.R.O.'s participation in measures to control the importation of pests and diseases, is the scientific supervision of the East African Plant Quarantine Station. Even before the 1934 conference mentioned above, imported plant material that might carry disease of potential danger to East African crops was quarantined by the Pathology Department of the East African Agricultural Research Institute at Amani. When E.A.A.R.I. closed down, a new quarantine station was built and financed by the three mainland territories and is administered by E.A.H.C. The reason it is sited at Muguga within easy reach of the E.A.A.F.R.O. laboratories is so that it can be under continual supervision of pathologists working there. It is my responsibility not only to see that all reasonable precautions are taken in handling imported and possibly infected plants but also to work out methods of implementing the policy indicated by the East African Standing Technical Committee on Plant Import and Export. Each species imported presents a new problem; whilst every endeavour is made to exclude exotic diseases, the needless destruction of suspect material in quarantine is as far as possible avoided. It is thus often necessary to seek the advice of specialists in fields other than my own stationed in Muguga or nearby institutions.

224. All plants are frequently inspected and an attempt is made to determine the cause of any abnormality seen. No plant known to be infected is ever released from quarantine, even if the disease can be definitely diagnosed as one already in the country. In such cases, if curative measures are known, they are applied. It is often possible to treat plants which, although certified free at source, arrive bearing aphids or other insects. This year fungicidal treatments have also been employed and apical cuttings have been taken from plants with infected roots. Other therapeutic treatments may be given as a routine measure, e.g. all sugar cane is treated against ratoon stunting disease before release to the grower, whether or not the causative virus has been found to be

present. When a disease is diagnosed as one unknown in East Africa, it is usually thought safer to destroy the affected plants. It was necessary this year to destroy a sugar cane variety and two others in contact with it when the presence of a bacterial disease was suspected. If no treatment is known, infected plants must always be destroyed.

225. Infection with fungi, bacteria, insects and nematodes usually result in obvious symptoms, but some viruses do not cause visible symptoms in all their hosts. It is the importation of symptomless carriers of virus diseases that is most to be feared and presents the greatest problems in quarantine. When possible, tests for the presence of viruses in symptomless plants are designed. Usually attempts are made to infect other known hosts either by sap inoculation or by grafting. For example sap is extracted from every known host of spotted wilt virus that comes into the quarantine station and is inoculated to a range of species known to show obvious symptoms if infected. Viruses have been found in chrysanthemums and dahlias by this method. Chrysanthemums which survived these tests are now being tested for the presence of other viruses by grafting to an indicator variety of the same species. Early this year the presence of virus was suspected in some imported Sweet potatoes and was proved when scions from the imported plants were grafted to healthy Sweet potatoes.

226. Microscopic examination may be useful in the diagnosis not only of diseases caused by visible pathogens but also of viruses which cause anatomical abnormalities. The presence of virus in dahlias has often been confirmed by this method and some bananas now held will not be released until they have been subjected to such an examination.

227. No plant can ever be released from the quarantine station until symptoms of all known diseases of that species have had the correct conditions and more than sufficient time in which to become apparent and unless all tests done give negative results.

228. Although E.A.P.Q.S. is not part of the E.A.A.F.R.O., the ultimate responsibility for the release or destruction of a plant rests with the staff of this organization. A list of the plants which it has been possible to release in five years' operation is given on page 107 of this report.

ANIMAL HUSBANDRY DIVISION

PIG MANAGEMENT STUDIES

W. J. A. Payne and A. F. Dent

229. A study has begun of the effect of farrowing equipment and the climatic environment in the farrowing pen on the incidence of piglet mortality. Conventional farrowing equipment is being compared with the round farrowing house, first introduced by the Ruakura Animal Research Station in New Zealand. The first results suggest that mortality is least in the heated, round farrowing house.

230. The possibility of artificially raising piglets once they have received colostrum from their dam is being investigated. It is believed that on the medium size and large pig farms a simple method of artificially raising piglets would be useful as at present many piglets are lost when their dam dies during farrowing, or if the dam looses her milk, or if she farrows a large litter. Also some sows farrow an insufficient number of piglets to make it worth the sow's while suckling them for eight weeks. Insufficient data has yet been obtained to decide whether artificial rearing of piglets is practical under farm conditions in East Africa.

MAIZE IN PIG NUTRITION

D. W. Duthie and A. F. Dent

231. In East Africa maize is used with caution in the rations of bacon pigs, since it has a reputation for producing soft, oily fats and low-grade carcasses. This is a great handicap in an area where production of maize exceeds local requirements, where many of the pig producers cannot grow barley, and where wheat by-products often have to be transported long distances from flour mill to farm. Yet on its chemical analysis maize should be an excellent cereal for pig rations, since it is very low in fibre and has an adequate protein content. A study is therefore being made of the nutritive properties of maize, with the objective of finding why maize is an unsatisfactory pig food and whether its detrimental properties can be corrected without increasing the cost of the ration beyond the economic level.

232. The first feeding trial of the series had the primary objective of finding the effect of maize on the hardness of carcass fat. The cereals in a standard barley, pollards, meat-meal ration were progressively substituted to give six rations containing 15, 30, 45, 60, 75 and 90 per cent maize, the crude protein content of the ration being fairly constant, between 14 and 16 per cent. The results showed a tendency for the fat to become softer (measured by the Hanus iodine value) as the percentage of maize in the ration increased, but all the fats were suitable for bacon curing. Feed conversion ratios did not show any significant effect of maize, but striking results were obtained when liveweight increase (between 100 and 200 lb.) was related to the percentage of maize in the ration. The 15 and 30 per cent maize rations gave average daily gains of 1.7 lb., but thereafter the gain dropped steadily to 1.0 lb. on the 90 per cent maize ration. It was inferred from this that the slowing down of growth had probably caused the tendency for the fat to become softer, as was suggested by Callow in 1931, and the regularity of the decrease in liveweight gain also suggested a nutritional deficiency in maize, probably nicotinic acid, one of the B vitamins.

233. In the second trial a ration containing 78 per cent maize, supplemented with a good mixed animal/vegetable protein concentrate, plus minerals, and with nicotinic acid added at the rate of 1 gm. per 100 lb. of the ration, gave an average daily liveweight gain of 1.7 lb. from 100 lb. to slaughter weight (200 lb.). The results of the first trial showed that, without nicotinic acid, a ration containing 78 per cent maize would probably give a daily liveweight gain of about 1.15 lb., and as the gain in this second trial was as good as that given by the 15 and 30 per cent maize rations in the first trial, it seemed that the nutritional deficiencies in maize had been corrected. A second group of pigs in this trial were given dried skim-milk equivalent to quarter of a gallon of fresh skim-milk per head per day, in addition to the ration fed to the first group, and their daily gain averaged 1.85 lb. On slaughter, eight of the ten pigs in the first group produced top-grade bacon carcasses, on the United Kingdom standard, while the remaining two were second grade. The ten pigs receiving additional skim-milk produced six top-grade and four second-grade carcasses.

234. Since the rations in the second trial cost no more than the standard barley/pollards rations used in East Africa, the results suggested that supplementary nicotinic acid would permit the effective use of high-maize rations. The more rapid growth of the

group receiving skim-milk, coupled with the fact that their average carcass grading was lower because of too much fat, indicated that this group may have been overfed, and that the optimum ration might be one containing less protein than that fed to the group without skim-milk.

235. Recent research work on pig nutrition in Britain and the U.S.A. has emphasized the importance of certain amino-acids in pig rations, and the relative proportions of the ten "essential" amino-acids also seems to affect the growth rate and efficiency of food conversions. Maize protein is said to be out of balance in regard to its amino-acids, and this study has now developed into one of finding which amino-acids in a high-maize ration are limiting for growth and carcass quality, and what type of amino-acid balance is required in the best ration. These investigations will include the growth period, from weaning to 100 lb., as well as the finishing period, from 100 lb. to slaughter weight.

THE CARRYING CAPACITY OF UNIMPROVED MUGUGA PASTURE

H. P. Ledger

236. Interim production figures for this trial in which 49 Zebu (Boran) steers were grazed on 70 acres of pasture, consisting of one third star grass (*Cynodon dactylon*) and two thirds couch grass (*Digitaria* spp.) were published in last year's annual report.

237. This trial was continued until June, 1958, when it was obvious that at this grazing density of $1\frac{1}{2}$ acres per beast the pasture could do little more than maintain animals of 900 lb. liveweight. The pasture had, in fact, deteriorated considerably during the last three months and badly needed resting.

238. The full production figures for the two years of the trial are given in Tables 1 and 2. This two-year period included the eight weeks during which the pasture was rested before the trial began, together with the 96 weeks during which the cattle continuously grazed the paddock. In each of the tables the mob has been subdivided into age groups according to the number of permanent teeth which were showing at the beginning of the trial, so that production figures for age groups as well as that for the whole mob are shown.

239. As might be expected, the younger animals have shown a slight increase in the liveweight gain per head per day over that of the older animals.

240. Reference to the overall gain/head/per day column in Table 2 shows that improving store cattle, i.e. those gaining in weight from 500 to 800 lb., were able to do so during the first 60 weeks at the rate of 0.75 lb. per head per day at a grazing rate of a beast to $1\frac{1}{2}$ acres. It is suggested that a figure of one beast to two acres should be a safe working figure for animals of this weight range. From 800 lb. onwards, however, it is obvious that the initial grazing density is far too heavy and it is possible that a density of one beast to three acres would be the more economic level during this fattening period. Of the 13 steers sent to the Kenya Meat Commission for slaughter one was graded "A" and the remainder "G.A.Q."

241. Over the two-year period the 70 acres produced 20,335 lb. liveweight or 145.3 lb. of live beef per acre per year. On the basis that this could be sold as G.A.Q. beef, killing out at 57 per cent, for which Sh. 1.10 per lb. carcass weight is paid: this represents a gross annual return of Sh. 91 per acre. This can be compared with the figure of Sh. 8-9 per acre generally quoted for the ranching areas of Kenya.

242. It is generally assumed that in the ranching areas one third of the gross return could economically be spent on improvements. On this basis up to Sh. 30 per acre per year is the maximum that could be spent economically on pasture improvement at Muguga.

TABLE 1

MEAN LIVEWEIGHT OF ZEBU STEERS IN LB. RECORDED AT 12 WEEKLY INTERVALS ON A MUGUGA PASTURE

	2 Teeth	4 Teeth	6 Teeth	8 Teeth	Mob	Date
No. Head	6	26	15	2	49	
Initial wt.	473	470	520	512	492	2–8–56
12 weeks	561	570	610	591	583	24–10–56
24 weeks	630	612	680	634	639	16–1–57
36 weeks	697	666	733	677	693	10–4–57
48 weeks	755	711	777	722	741	3–7–57
60 weeks	835	782	845	777	810	25–9–57
72 weeks	862	816	871	803	834	18–12–57
84 weeks	924	861	925	830	886	11–3–58
96 weeks	946	886	931	845	907	4–6–58

TABLE 2

MEAN DAILY LIVEWEIGHT GAIN PER HEAD OF THE ZEBU STEERS IN LB. RECORDED FOR 12 WEEKLY PERIODS

	2 Teeth	4 Teeth	6 Teeth	8 Teeth	Mob	Overall L.W.G. lb./hd./day	Date
12 weeks	1·05	1·19	1·07	0·94	1·06	1·06	24–10–56
24 weeks	0·82	0·53	0·83	0·51	0·67	0·87	16–1–57
36 weeks	0·80	0·64	0·63	0·51	0·64	0·79	10–4–57
48 weeks	0·69	0·54	0·52	0·54	0·57	0·74	3–7–57
60 weeks	0·95	0·84	0·81	0·65	0·81	0·75	25–9–57
72 weeks	0·32	0·40	0·31	0·31	0·30	0·68	18–12–57
84 weeks	0·74	0·53	0·64	0·32	0·62	0·67	11–3–58
96 weeks	0·26	0·29	0·07	0·25	0·25	0·62	4–6–58
Mean overall gain in lb./ hd./day.	0·70	0·62	0·61	0·50	0·61	0·61	

CARCASS EVALUATION

H. P. Ledger

243. During the year 24 Boran steer and seven Boran cow carcasses have been analysed and it is evident from a comparison of these analyses for *Bos indicus* with similar analyses for *Bos taurus* carried out in the U.K. that there are some fundamental differences in the composition of the carcasses of the two species. These differences are being investigated and the results of such investigations will be submitted for publication in the appropriate journals.

244. There is one difference between the method of recording now used and that reported in last year's annual report. Cattle are no longer killed on the station and thus there are no offal records available. Whilst in some respects this is regrettable it is the outcome of practical considerations. Thanks to the full co-operation of the Kenya Meat Commission all cattle are now slaughtered at their Athi River factory and a side from each animal is returned to Muguga for dissection. A member of the research staff is given every facility to follow the animal through the factory and this ensures that carcasses are dressed in such a manner as to render them experimentally comparable without losing commercial significances. The main advantage of this arrangement is the increase of from one to four in the number

of carcasses that can be dissected in any one week. As the carcass is given a commercial grading it is also possible to provide information of practical importance from the data obtained. There is also the financial advantage that the cost of research is considerably reduced owing to more efficient disposal of the unwanted material.

245. It is clear that one of the more important problems requiring a solution is that of determining the total fat percentage both in the live animal and in the carcass.

246. *In vivo* estimations of total fat percentages have been made, in collaboration with Dr. Rogerson of the East African Veterinary Research Organization, using the antipyrine dilution technique. The results have, so far, been disappointing, as comparison between them and those of the dissection of the carcasses of the animals under test have been inconsistent.

247. At the request of Dr. H. Hutchinson of the Tanganyika Veterinary Department, and in collaboration with him, work was undertaken to investigate the best position at which the tenth rib should be cut if a reasonably accurate estimate of the composition of a carcass was to be made from an analysis of this joint. The preliminary results (Tables 3 and 4) in so much as they refer to mature Boran cattle indicate that an analysis of the full tenth rib joint including the flank is likely to give a very good indication as to the composition of the carcass as a whole.

TABLE 3

Sample Rib Cut at Position	Correlations		
	Bone	Lean	Fat
1. Eye muscle end	0·66	0·73	0·77
2. Short fat A end	0·76	0·71	0·75
3. ½ length of rib bone ..	0·79	0·79	0·77
4. 61·5% length of rib bone ..	0·77	0·80	0·78
5. Full length of rib bone ..	0·75	0·90	0·84
6. Full rib and flank	0·87	0·92	0·93

Prediction equations (Y = tissue in 10th rib)

Bone % = 0·760Y + 6·08

Lean % = 0·703Y + 24·89

Fat % = 0·685Y − 1·01

TABLE 4

USING PREDICTION EQUATIONS

Brand No.	Fat %			Lean %			Bone %		
	Est.	Actual	Diff.	Est.	Actual	Diff.	Est.	Actual	Diff.
Cow 251	34·92	35·99	−1·07	52·89	52·56	+0·33	11·95	11·45	+0·50
Steer 491	30·65	32·24	−1·59	57·50	55·88	+1·62	11·70	11·88	−0·18
Steer 507	31·70	31·39	−0·31	55·58	55·84	−0·26	12·61	13·07	−0·46
Cow 645	28·57	29·08	−0·51	59·29	59·33	−0·04	12·08	11·59	+0·59
Steer 503	29·73	28·18	+1·55	57·05	58·00	−0·95	13·20	13·82	−0·62
Steer 509	25·76	26·81	−1·05	61·44	60·10	+1·34	12·87	13·09	−0·22
Cow 254	22·93	22·26	+0·67	60·29	61·27	−0·98	17·27	16·47	+0·80
Cow 566	22·23	22·02	+0·21	61·20	60·57	+0·63	17·04	17·41	−0·37
Steer 512	20·92	21·01	−0·09	63·27	62·99	+0·28	16·26	16·00	+0·26
Steer 146	6·97	7·36	−0·39	78·25	75·90	+2·35	15·54	18·56	−3·02

EXPERIMENTAL FARM

A. F. Dent

248. Approximately 25–30 acres of the land handed over by the Forestry Division have been put down to star grass, a good crop of oat straw and hay being first harvested. The rainfall, which to date is above average, has enabled the star grass to become well established. The method of reseeding pastures has been as follows: star grass has been planted vegetatively at the beginning of the long rains and allowed to become established for about one month, after which a light crop of oats has been planted. The oats are later harvested for straw and hay and the grass is allowed to grow, the gyromower going over it once or twice before allowing cattle to graze the area. This method of reseeding appears to be completely satisfactory providing the long rains are favourable.

249. Extensions to the main pig-house have been built for the storage of foodstuffs and machinery for the milling, mixing and pelleting of food is to be installed. This will be a great improvement on the present system of hand mixing. Two round-house pattern farrowing pens have been fitted and minor alterations made to the other four pens. An electricity supply is now available in the pig-house and in all farrowing pens. A new layout of the sow paddocks has been completed but water has not yet been laid on.

250. *Identical Twin Cattle.* A herd of sets of identical twin cattle is being established but in spite of circulars to farmers and

advertisements in the Press, etc., this is proving to be rather a slow process and the formation of this herd will take some time.

251. *Pigs.* A Landrace sow has been purchased and a boar of the same breed is on order. A Wessex gilt has been presented to the Division by Mr. C. Moore of Pioneer Farm, Karen.

252. *Sheep.* This unit is being closed down and the sheep sold.

253. *Crops:*—

(*a*) *Potatoes.* These were planted on some of the agricultural rotation experimental plots during the long rains.

(*b*) *Lupins.* The Blue Lupin was also planted on these experimental plots during the long rains and yielded quite well.

(*c*) *Beans.* These were grown on the agricultural rotation experimental plots during the short rains.

(*d*) *Oats.* The star grass pastures planted during the year were oversown with oats, which yielded a very good crop. Part of this crop was almost lost due to the breakdown of the baler during harvesting and the unavailability of spare parts. The E.A.V.R.O. baler was borrowed, however, and the crop was saved. At Muguga it has been found that the oat grains do not fill out satisfactorily and the crop is therefore grown purely for high quality oat straw.

(*e*) *Kale.* Sufficient Kale was grown during 1957 to meet this year's requirements. During 1959 an area below the piggeries will be planted with Kale as green food for the baconers.

(*f*) *Sweet Potatoes.* No sweet potatoes were planted during 1958 as there was sufficient from last year's planting.

(*g*) *Rhodes Grass.* A good crop of hay was harvested from the small area under Rhodes grass. During 1959 it is intended that two fields should be put down to Rhodes grass for hay, an increased quantity of which will be required as soon as the cattle unit is in full swing.

254. *Pastures.* The fields reseeded in 1956 and 1957 seem to be standing up to heavier grazing than the fields which have not to date been reseeded; the best fields are those which were reseeded in 1957.

255. A programme of reseeding to be completed by 1962 has been drawn up and by then the reseeding at least once of all permanent pastures will have been completed. This will enable an assessment to be made of the life of the pastures.

256. Small areas are to be oversown with Kenya wild white clover as well as lucerne and *Medicago denticulata* will be used to replace oats as a nurse crop on some fields in order to obtain some lucerne hay.

FORESTRY

SILVICULTURAL RESEARCH

A. L. Griffith and P. Howland

257. Once again work has, in general, continued on the long-term lines laid down for us by the E.A. Advisory Council in 1952. The main emphasis has been on the Information Section, softwood problems and the development of Muguga estate for experimental purposes.

258. The Silviculturist was on leave from 15th March to 17th July. During his leave the Silviculturist visited the Italian Forest Department and the Forestry Division of F.A.O. in Rome, the French Colonial and Metropolitan Forest Departments in Paris, the French Tropical Forest Research Organization at Nogen-sur-Marne, the French Forestry Educational Organization at Nancy, the Swiss Forest Department at Zürich, the Portuguese Forest Department in Lisbon and Madeira and the U.K. Forestry Commission in London.

259. The Sixth Forestry Course was held in November, 1958, and was attended by 15 officers including an A.C.F. from British Somaliland. The Uganda delegation included three African Foresters. We were unable to hold the second half of the course at Molo in the Londiani Division of Kenya owing to accommodation difficulties, and instead two day trips from Muguga were arranged. We are grateful to the Chief Conservator of Forests, Kenya, for this facility.

260. On 2nd October we had a visit of a week's duration of the Forest Ranger Class of the Tengeru Natural Resources School of Tanganyika. The Kenya Divisional Forest Officers Conference visited us in December. In April we had a visit by the Inter-African Phyto-Sanitary Commission.

261. In July the Silviculturist attended the second Inter-African Forest Conference at Pointe Noire in French Equatorial Africa. This was followed by study tours in the forests of the Moyen Congo and the Gabon. The main points of interest at this conference were the finalization of the Nomenclature of African Forest Formations and the decision by C.C.T.A./C.S.A. to hold an experts conference on the Dry Types (chiefly of the Miombo *Brachystegia–Isoberlinea* complex) at Ndola in July, 1959.

262. The headings of the report that follows are those of the long-range programme:

I. INFORMATION SERVICE

263. The Forest Bureau was maintained and expanded and now contains 1,950 Specific Ledger Files and 891 General Ledger Files. The service of issuing periodically lists of highlights of information ledgered has been continued and has proved very popular. Many enquiries were received and answered and we have been happy to welcome many visitors, official and unofficial, from all walks of life and business who came to see for themselves the various species of trees and hedges actually growing.

II. STANDARDIZATION OF RESEARCH PROCEDURE

264. Several modifications of our research procedure were carried out.

III. RESEARCH ON SOFTWOODS

265. In the following report on seed and nursery problems, Mr. W. B. May (Horticulture) and Mr. P. Dickinson (Plant Quarantine) have both collaborated. It must be remembered that for nursery and short-term work the planting season is the long rains in April and May and all experimental work is finally measured about March each year. The calendar year report thus includes the end of the previous year's work and the first nine months of the current year's work (but without having reached any measurements or results).

A. Seed Problems

266. *Cotyledon Numbers.* On germination in the nursery, several species were found to produce different numbers of cotyledons. These plants were kept separate by cotyledon numbers and planted out in short-term experiments, but were found to produce no differences in height growth or survival percentage at the end of the first year. Long-term experiments were planted out in 1954 (E.P.4a) and 1955 (E.P.4b) with *C. lusitanica* of two, three and four cotyledons, and in 1954 (E.P.7) with *Pinus patula* of four to nine cotyledons, *Pinus caribaea* (now called *P. elliottii*) of four to nine cotyledons, *Pinus radiata* of seven to nine cotyledons and *Cupressus lusitanica* of two to four cotyledons. In 1958, after three

and four years growth respectively, no significant difference in height growth or survival percentage have resulted.

267. *Size of Seed.* *Cupressus lusitanica* seed was found to vary in size very considerably. The seed was selected into five sets—

(*a*) which would pass through a sieve of ten meshes to the inch;

(*b*) to (*d*) which would pass through sieves of 9, 8 and 7 meshes to the inch respectively, and

(*e*) seed too large for a seven-mesh to the inch sieve.

The resulting plants were planted out in short-term experiments and produced no differences in height growth or survival percentage after one year. Long-term experiments were planted out in 1954 (E.P.3a) and 1955 (E.P.3b), and so far, after three and four years respectively, the different sizes of seed have produced no differences in height growth or survival percentage.

268. *Seed Orchards.* Work on the technique of grafting under field conditions (Mr. May) and under glasshouse quarantine conditions (Mr. Dickinson) continued, but was hampered by both officers being on leave during the year. In 1957, a trial sample of grafting material of elite *Pinus radiata* was obtained from Australia. This trial sample arrived in good condition and a high percentage of grafts was successful. This shows that the method is possible. A second consignment was held up by the Australian quarantine authorities as it was suspected of both a rust and a fungus, neither of which is at present known in East Africa.

269. Recent work has therefore had to be with local material. One difficulty is that the area of *Pinus radiata* in East Africa is at present comparatively small, and most of it is young. We do not yet really know what an East African elite *P. radiata* tree is, and what qualities we should breed for. We are therefore working with what we at present consider our best trees, but call them plus trees and not elites.

B. Nursery Problems

(*Experiments started in April,* 1957 *and concluded in March,* 1958)

270. Experimental work in the nursery at Muguga has continued. This is long-term work, for many years of repetition are required to cover the climatic range. Weather variations have been very great and in the past six years, 1952 was nearly normal, 1951,

1954 and 1957 were above average and 1953 and 1955 were well below average. 1956 with 27.9 in. was below the normal of 36.4 in., but like 1955, the rain was well distributed and the planting "take" and subsequent growth were good. 1958, so far, has been rather above average, though the dry season of September and October was severe.

271. *Comparison of different pine soils.* This project was concluded during the year. The 1957 experiment confirmed the previous work that under Muguga conditions the addition of pine soil is not necessary in the nursery and that a good balanced soil mixture (Muguga Standard Mixture which contains a basic quantity of N.P.K.) has produced better plants than boxes with a pine soil inoculation. Experiments have been carried out annually since 1954 to compare the results obtained with pine soils from under the oldest pine plantations of different species from different places. The soil used was that of the first three inches below the undecomposed litter from *P. patula* and *P. radiata* stands at Kinale and Kitiro. Survival percentages have been high and varied from 94 to 100 per cent. The four years of experiment indicate that the two species used (*P. patula* and *P. radiata*) do not show any preference for their own soils (i.e. for possibly specific mycorrhizae), at all events under Muguga conditions, but that the four soils used are merely of different qualities. In the eight experiments over four years with both species the soils have sorted themselves out in the same order each time.

272. *Fertilizers.* The experiments described in previous years' reports were repeated in 1957 and measured in 1958. They were with *P. patula* seedlings. We have now six years' repetitions. N.P. and K were applied in all combinations, and at two rates which were:—

Fertilizer rate 5.	N.	Sulphate of ammonia (20 per cent N) 540 lb. per acre or 8 gm. per box.
	P.	Double super phosphate of lime (39 per cent soluble P_2O_5) 540 lb. per acre or 8 gm. per box.
	K.	Sulphate of potash (52 per cent K_2O) 270 lb. per acre or 4 gm. per box.
Fertilizer rate 10.		Twice the above quantities.

The experiments confirmed the indications previously obtained which were:—

(*a*) The response to fertilizers varies with the annual rainfall, being greater (about 30 to 33 per cent) in a normal to wet year than in a dry year (about 10 to 15 per cent).

(*b*) There is very little difference in response between the "5" and "10" rates of application and hence the latter rate is unnecessarily high.

(*c*) The effect of application of the fertilizer 12 weeks after pricking out is very small compared with application six weeks after pricking out.

(*d*) The pine seedlings gave the largest response to the nitrogen fertilizers and the smallest to the potash and phosphate.

(*e*) All the experiments made in the last seven years have shown that the application of a basic quantity of N.P.K. is a well worth while insurance. The quantity used is small, 3 oz. per square yard of bed or half an ounce per box, but it ensures that the basic nutrients are present.

273. The above experiments were replicated interterritorially and these 16 experiments confirm the above indications. They however do indicate that in some cases considerable work is still needed to improve the soil structure and soil texture of the nursery to raise the nursery stock to a reasonable standard. Fertilizer alone is not sufficient nor is it the primary consideration.

274. The experiment was repeated in 1958 with *P. patula* in Muguga Standard Mixture, but with no basic N.P.K. added.

275. *Minimum Fertilizer Requirements.* The experiments described above show that the two levels of fertilizer application have in general produced the same response. Experiments were therefore started in 1955 to measure the response of seedlings to lower rates of fertilizers. Three years' experiments with two pine species have so far failed to show any appreciable response to fertilizer application of less than rate "5" described above.

276. The experiment was repeated in 1958 with both *P. patula* and *P. radiata* but with Muguga Standard Mixture without basic N.P.K. and with Muguga Standard Mixture without both N.P.K. and horse manure. This was to ensure that the soil had no fertilizer in it initially.

277. *Organic and Inorganic Fertilizers.* The experiments to test whether tree seedlings respond to organic fertilizers whose nutrients are likely to become available over a period of time, than to inorganic fertilizers, were continued. The organic fertilizers used were dried blood and hoof and horn as nitrogen sources and bone meal as a phosphate source (though this probably contains a certain amount of nitrogen as well). The levels of application were approximately the same as in the previous experiments and the plants were seedlings of *P. radiata* and *P. patula*. The project was concluded this year as three years of experiment have indicated that the organic fertilizers give approximately the same growth response as the inorganic at the end of the first year and are very much more expensive.

278. *Transplant Spacing in Beds.* The experiment was continued in which the plants were pricked out at two by two, three by three, and four by four inches. Wider spacing was not used as the experiment had to keep within practical economics. In the three years of experiment there was in general little difference in height growth or survival percentage between treatments, but the wider the spacing the sturdier and better developed the plant. It remains to be seen how they behave when planted out. It was not possible to compare the treatment by the weight of the plants produced as the stock was needed for planting out experiments. The experiment was repeated in 1958.

279. *Effect of Restricting Evaporation in Transplant Boxes.* This subject was continued. Treatments were: (*a*) Boxes sunk to ground level; (*b*) Boxes placed normally on a gravel base, and (*c*) Boxes placed normally on a gravel base but mulched with chopped straw after the short rains, i.e. for the dry season of January, February and March. The species used were *P. patula* and *P. radiata*. The results of the first three years' work are that the sunk boxes and the mulch increased the height of the *P. radiata* by 10 per cent and 4 per cent and of the *P. patula* by 23 per cent and 17 per cent respectively, again demonstrating that *P. patula* is much the more sensitive of the two species concerned. It should be noted that sinking the boxes is much more expensive, as (*a*) they have to be dug up frequently for root pruning, and (*b*) wear and tear and termite damage to boxes is severe.

280. Although much more repetition is required, it appears unnecessary to sink boxes if one is prepared to water adequately. It is definitely worth while, however, to mulch boxes of *P. patula* during the hot dry weather. The experiment was repeated in 1958.

C. Short-term Planting-out Problems

281. These short-term experiments were started in 1952 to compare different establishment techniques. So far 86 experiments have been completed and 11 have been started in the long rains of 1957. The results as summarized are only tentative as the experiments must be repeated for a number of years in order to cover the climatic range.

282. A summary of the first five years' results of this work, which was presented to the Seventh British Commonwealth Conference, is as follows:—

(*a*) The unreliability of the climate, both seasonal and annual, has been determined.

(*b*) Only the very best nursery stock should be used and the quality of this stock can be raised by improving the texture and composition of the local soil by the addition of local ingredients. It is necessary to add a small quantity of N.P.K. to ensure that the basic nutrient elements are present. Early pricking out of seedlings within one or two weeks of germination is essential.

(*c*) The nursery stock should be planted out as early in the planting season as is reasonably safe. This "earliest safe date" can be determined by keeping a daily record of the rainfall build up after an arbitrary date (as distinct from the total rainfall and allowing for probable daily evaporation) together with a periodic estimation of the depth of soil wetting.

(*d*) The plants can with advantage be planted in the field deeper than they were grown in the nursery. This deep planting can be as much as burying up to one third to one half of the stem without deleterious effects, thus initially putting the roots of the seedlings in the deeper layers of the soil which dry out more slowly in case of an early break in the rains or an early cessation of the rains.

(*e*) Even bare-rooted stock can be stored in wet gunny for as long as 48 hours after lifting in the nursery if necessary without deterioration. This time of storage of course should be kept to a minimum.

(*f*) Exposure of the plants between the time of lifting in the nursery and planting in the field, even for as short a period as 15 to 30 minutes, can be fatal, and such exposure should be avoided at all costs.

(*g*) Early weeding in the first two years has a very marked effect on the crop. The retarding effect on height growth of deep rooted grasses may be of the order of 150 per cent after two years. It is essential that efficient early weeding is carried out as it gives the plant crop its best chance against the weeds and thus considerably reduces early maintenance costs.

283. *Planting Stock from Different Dates of Sowing in the Nursery.* This project is now concluded. With *P. patula* the sizes of the plants have ranged from 2 to 15 inches. Measured after a year the increment and vigour of the larger plants has been the best, and except with the smaller plants (6 inches and under) survival percentage has been good. With *P. radiata,* plants put out have varied in size from 3 to 25 inches. Survival percentage for all sizes has been very good. Again within the range used, the bigger the plant the greater the increment and vigour. This species is very hardy and it appears unnecessary to use plants larger than those that can be raised in the nursery in one year with our present techniques. The sizes of *C. lusitanica* used has varied from 3 to 30 inches. Survival percentage has been very good indeed except for the smaller sizes. Again the bigger the plant the better the increment and vigour. With this species it appears that post long rains sowings will produce plants sturdy enough for the purpose.

284. *Different Dates of Planting.* We have now five years' experimental evidence of weekly planting from the middle of March to the end of May each year for *P. patula, P. radiata* and *C. lusitanica.* With all three species height growth and survival percentage drop markedly with late planting. In these experiments an estimate of depth of soil wetting is made and from the rainfall records the rainfall "build-up" is calculated allowing for daily evaporation.

285. The indications of these experiments are that the criteria for the earliest safe date for planting at Muguga are:—

(*a*) Planting should not be started before 15th March.

(*b*) The critical rainfall "build-up" is about $\frac{1}{2}$ to $1\frac{1}{2}$ inches.

(*c*) The critical depth of soil wetting is about 2 to 3 inches for *P. patula* and 1½ to 2 inches for *P. radiata* and *C. lusitanica*.

All these three criteria *must* be fulfilled at the same time for safe planting.

286. It is not suggested that these conditions apply to areas other than Muguga. They are given as a demonstration of a method of estimating the possibilities of success in planting in areas which are climatically difficult.

287. *Comparisons of Different Depths of Planting.* Eight experiments with *P. patula, P. radiata* and *P. leiophylla* have been done in the past four years in which plants were planted (*a*) at the collar, (*b*) two inches above the collar, and (*c*) four inches above the collar. In no case has deep planting caused any deleterious effects, but has caused a stimulation of height growth of from 10 to 30 per cent. Similar results have been obtained in N. Carolina of the U.S.A. with *P. taeda, P. rigida, P. virginiana* and *P. echinata*. This practice of deep planting may prove even more beneficial under more unreliable climatic conditions than those of Muguga, for it tends to put the root systems of the very young seedlings into the deeper layers of the soil.

288. *Comparison of Bare-rooted and Ball-planted Transplants.* Several experiments have been done over the past four years with *P. patula* and *P. radiata*. Results have been very variable and indications so far are that in Muguga conditions it is well worth while to take extra trouble and small expense and use ball-planted plants. The small gain in cost is not worth the risk of using bare-rooted plants except under the most favourable conditions.

289. *Comparison of "Normal" and "Overgrown" Nursery Stock.* This project was concluded during the year. The experiments were with *P. patula* and *P. radiata* and the plants were from beds and boxes, both one and two years' old. The indications are that it is not economically worth while to grow the much more expensive, older and larger plants.

290. *Effect of Storage of Naked Rooted Stock.* The project was concluded during the year. Stock of both *P. patula* and *P. radiata* was lifted and all soil shaken off the roots. It was then bundled in wet gunny, taken to the planting site and one set planted immediately. The second and third sets were thoroughly

wetted and left from 24 to 48 hours respectively. The indications of four years' work are that *P. patula* is more sensitive than *P. radiata*, but that both species *can* be stored thus for 48 hours if necessary. The practice is to be deprecated and planting should be done as soon after lifting as possible.

291. *Effect of Exposure of Naked Rooted Stock.* Parallel to the above experiment, naked rooted stock of *P. patula* and *P. radiata* were (*a*) planted at once, (*b*) exposed for 15 minutes, (*c*) exposed for 30 minutes, and (*d*) to (*f*) exposed for one hour, three hours and six hours. Three years' experiments have shown that any exposure of even as short a period as 15 minutes can be fatal. This demonstrates the need for careful supervision of the storage of plants between lifting in the nursery and planting in the field.

292. *Planting Stock Raised by Different Box and Bed Techniques.* The project was concluded during the year. The experiments were continued and the results of four years of experiment show that under Muguga conditions it is not worth while to use the cheaper bed method. The use of boxes is more expensive, but it is a worth while insurance against failure in adverse weather conditions.

293. *Cover Crops in Young Cypress Plantations.* Modern methods of pruning and thinning cypress and pine tend to keep the plantations open in the early stages and vulnerable to invasion by grass. An experiment was started in 1954 (E.P.5) to try and introduce a cover crop in a one-year-old cypress plantation that would keep grass out. The cover crops tried were *Prunus salasii, Tephrosia vogellii, Centrosema pubescens* and *Pueraria javanica.* At four years old the best crop is the *Prunus* which is seven feet high. It looks very healthy and is doing its job. The *Tephrosia* which was best last year is about six feet high and still good, but apparently is getting to the end of its life. The *Centrosema* and the *Pueraria* are complete failures. During the past year *Neoboutonia macrocalyx* has come naturally into some of the control plots. It is about six feet high and appears to be a very useful natural cover crop.

294. *Effects of Shamba Crops and Cultivation.* An experiment was started in 1955 (E.P.11) in conjunction with the soil physics division to study the effects of *shamba* crops and cultivation on the height growth and survival percentage of the forest crop. The first year's work was ruined by the ravages of buck and

porcupine on the *P. patula*. The plot was fenced against the pests and replanted with *P. radiata*. It was very soon realized that different depths of cultivation were impossible to control and so the experiment has developed into the effects of *shamba* crops on forest crop. The *shamba* crops were (*a*) maize, (*b*) beans (*c*) maize and beans together. The general result at the end of the first year was that the *shamba* crops reduced the growth of the forest crop by about 10 per cent in height. They had no appreciable effect on the survival percentage which was in general high and from 96 to 98 per cent. At the end of the second year survival percentage was still the same and the general depressing effect of the *shamba* crops on the forest crop was still 8 to 11 per cent. It is still to be seen if this depressing effect continues after the pines are too high to allow intercropping or whether the initial set-back fades out.

D. Long-term Problems

295. The experiment started in 1955 (E.P.8) to determine the effect of the season of pruning on the rate of wound occlusion of *C. lusitanica* was closed during the year. This was part of our interterritorially replicated series of experiments.

296. The Muguga experiment showed that there is apparently no effect on occlusion of season of pruning in Kenya east of the Rift, nor in Uganda and Tanganyika. In Kenya west of the Rift the best season of pruning appears to be during or just before the long rains.

297. With the sizes of branches pruned in these experiments complete occlusion occurs in about $1\frac{1}{2}$ to $2\frac{1}{2}$ years. In the warmer climate of Uganda occlusion occurs rather quicker.

298. In this experiment, trees regenerated from seed and vegetatively propagated trees were compared. The vegetatively propagated trees in general had large branches to start with but the rate of occlusion was roughly the same for the two classes. On this account the period taken for occlusion was of course longer for the vegetatively propagated trees although of the same age.

299. The second experiment at Muguga (E.P.12) to determine the rate of radial direction of the occlusion of the wound was also concluded during the year. In this experiment measurements were taken on four radii at right angles on each wound. On the initial wounds the biological centre of the wound was seen

not to be at the geometrical centre, but was displaced 7 per cent above and 5 per cent to the left of the latter. The rate of occlusion was roughly the same in all directions for the first nine months but then greatly accelerated from the bottom of the wound. After 30 months the radii right and above the biological centre were totally occluded and the radii left and below the biological centre occluded two months later. Thus the occlusion was to the biological centre and not to the geometrical centre. This is a most important fact to have established as the wound tissue most susceptible to successful attack by *Oemida* and *Androeme* is the heart wood or dead wood that is concentrated around the biological centre of a wound.

300. We have two sample plots of *Eucalyptus saligna*. S.P.1, of 0.6 acres is now 42 years old and measurement in 1957 showed it had a top height of 145 feet and a mean diameter of 18.9 inches. The plot was established in 1952. Over the last five years the mean annual height increment has been 1.2 feet and the mean annual diameter increment 0.2 inches. Thus at this age and size it is still growing well. By measurement of crown cover the plot is only 60 per cent stocked. The number of stems per acre is 34.

301. S.P.2 is now 15 years old and one acre in extent. The plot was established in 1953. Measurement in 1958 showed it had a top height of 82 feet and a mean diameter of 8.5 inches. Over the past five years the mean annual height increment has been 2.6 feet and the mean annual diameter increment 0.4 inches, thus showing that at this age and size it is growing very fast. The plot is fully stocked and the number of stems per acre is 140. It is of interest that although in 1953 the plot was heavily thinned from 270 to 140 stems per acre, from 55 to 32 square feet basal area per acre and from 1,665 to 995 cubic feet per acre, by 1958 the basal area per acre had already recovered to 54 square feet.

302. An experiment (E.P.17) was started during the year to test the effect on height and diameter growth of *Pinus radiata* of annual pruning to one half tree height, two thirds tree height and threequarters tree height up to 30 feet. The crop is at present three years old.

303. Sample plots are being established in *P. radiata* and *P. patula* and *C. lusitanica* crops.

E. Species Trials (Mainly Exotic)

304. *Arboretum*. Nine new plots were planted in the arboretum of small trial plots. These were of *Hakea saligna*,

Eugenia jambolana and *Bambusa vulgaris*, and six plots of *Pinus patula* raised from Kenya plus trees. The object of the arboretum is to compare the growth and survival of each species or strain. Untended specimen trees are grown of each species as well as a one-tenth acre plot which is pruned and thinned according to normal plantation practice. The aboretum now includes:

Eucalypts	48 plots (43 species)
Pines	36 plots (24 species)
Cypresses	17 plots (15 species)
Callitris spp.	3 plots (3 species)
Acacia spp.	14 plots (10 species)
Others	53 plots (53 species)

A total of 171 plots and 148 species.

305. *Fungal diseases in the arboretum.* An outstanding feature of the arboretum has been the demonstration of pests and diseases. So far in six years the cypress canker (*Monochaetia unicornis*) has killed over 50 per cent in the *Cupressus macrocarpa* plot and most of the remaining trees show the disease, while in the adjacent *C. lusitanica* plot only 2 per cent have been killed. It appears likely that serious loss from this disease will occur in the near future in the *C. pygmaea* plot, 33 per cent already having been killed.

306. *Insect pests in the arboretum.* The *Eucalyptus* weevil (*Gonipterus scutellatus*) first appeared in 1955 and so far 23 species have been attacked, several of them seriously. The heaviest attacks have been on *E. camaldulensis, E. globulus, E. maideni, E. nova anglica, E. robusta, E. tereticornis* and *E. viminalis.*

307. *Bacterial symbiosis in the arboretum.* In collaboration with Dr. Millbank (Microbiologist) the roots of plants of some species normally connected with bacterial root nodules were washed out in April, 1958, with a hand pump. Root nodules were found on *Acacia decurrens* of local, South African and Australian origins, on *Ac. mollissima* of local and Australian origins, and on *Ac. pycnantha* of South African origin. They were not found on *Robinia pseudo-acacia* of South African origin, on *Castanospermum australe* of local origin, on *Casuarina torulosa* of Amani, Tanganyika, origin, nor on *Casuarina montana* of Indonesian origin, although the roots of this species carried nematode galls.

308. Some species in the arboretum have shown remarkable growth. They were measured in March, 1958, and their top heights

were given in last year's report (the top height is the mean height of the tallest 100 trees per acre, i.e. ten per plot). The diameter given is the mean d.b.h. over bark of all trees in the plot. Some of the eucalypts now are nearing 60 feet top height and 6 inches diameter in 6½ years. A number of the plots were thinned during the year.

309. *Live hedges.* One new species was added during the year, *Solanum potatorum*, and is already up to the normal standard of 5 feet high and 4 feet wide. It was raised as transplants from local seed. Of the original species the slower growers, *Aberia caffra* (Kei apple) and *Rosa multiflora*, are up to full size although the rose was badly browsed by buck in the early stages.

310. *Interterritorial Eucalypt trial.* This trial (E.P.15) is a series of five replicated plots, of each of 12 species or strains of eucalypts, and is now nearly two years old and growing well. It is part of a project of the International Union of Forest Research Organizations and is being repeated in some 16 different countries. The Muguga trial, however, is the only one near the equator.

IV. GERMINATION AND V. REGENERATION OF HARDWOODS

311. Further work was done in the territories. E.A.A.F.R.O.'s contribution was purely advisory.

VI. SHORT-TERM TREE CROPPING

312. The replicated ten-acre experiment to test the relative fuel yields of three eucalypts is now three years old and growing well. Height differences between species are still very noticeable. The species are *E. grandis* of Australian origin, *E. saligna* of Australian origin and the local *E. saligna* hybrid. The striking difference is that *E. grandis* has now completely shaded out the ground cover while that under the two *E. saligna* species has only about 50 per cent disappeared. It appears that the size of the fuel required for E.A.A.F.R.O. purposes will be reached at five or six years old. This experiment will of course not only be used for the testing of fuel yield but for the yield of future coppice rotations and the stool mortality rotation by rotation. The relation between stacked and solid cubic volume, the density per cubic foot and the calorific values of the three species will be measured.

313. The arboretum plots have shown that we have several other species of eucalypts which grow faster than the local *E.*

saligna, and much bigger experiments with these species will have to be done if we are to find our best economic fuel and pole producers. Some of these rapidly growing species such as *E. globulus* are ruled out where the weevil flourishes. An experiment (E.P.16) has been established in the *Eucalyptus saligna* (Kenya origin) plantation of 1952 to determine the fuel yield per acre at the end of the first and subsequent rotations. The plantation is at present being felled.

314. Another experiment (E.P.18) has also been established in this plantation to determine the stool mortality rotation by rotation using different methods of felling (e.g. by saw and by axe).

VII. YIELD TABLES FOR IMPORTANT SPECIES

315. The plot data from Uganda and Tanganyika have been received and processed and are fitting in very well in the tentative graphs. The Kenya data are not yet available.

VIII. MUGUGA (E.A.A.F.R.O.) ESTATE

316. Maintenance of the estate was continued and the work chiefly consisted of the conversion of the wattle to softwoods for experimental purposes and to eucalypts to provide fuel and poles for the station. With the 1958 planting the conversion of the estate from wattle to the experimental crops for agriculture and forestry should have been virtually completed, but owing to a failure in the nursery (the first we have ever experienced) we were only able to plant 13 acres out of the 70 acres planned. This year we felled the first eucalypt plantation planted by us in 1952. It was originally spaced at 8 by 8 feet and was 20 acres in extent. At six years old it yielded 610 poles per acre or approximately 3,250 stacked cubic feet per acre, a total of 62,500 stacked cubic feet.

317. We frequently get visits by parties such as the forestry classes of the Tanganyika Ranger Schools at Tengeru and Olmotonyi. For their accommodation a camp site has been completed. It has been grassed, fenced and equipped with water, sanitation and cooking facilities.

FOREST ENTOMOLOGY

W. Wilkinson

318. This division has been in abeyance from April, 1957, when Mr. Gardner retired, until November, 1958, when Mr. Wilkinson, the first of our two new forest entomologists, arrived.

HORTICULTURAL SECTION

W. B. May

Forestry Work

319. All the forestry nursery experiments referred to in the report of the Silviculturist were carried out by the Horticulturist. He is also raising an adequate number of plants of 25 tree species for planting in the Arboretum in 1959. He has been co-operating with the Silviculturist of the Kenya Forestry Department in grafting living material from selected trees of *Pinus patula* on to young stock for the production of a seed orchard containing only carefully selected trees from the whole of the forested area.

Horticultural Work

320. Floral decorations were provided for the East Africa High Commission stand at the Nairobi Royal Agricultural Society's Show. Shade trees have been planted around the new High Commission building, and the window boxes in this building are planted and maintained by the Horticulturist.

Tours

321. The Horticulturist visited a number of nurseries belonging to the Uganda Forestry Department in November and December at their invitation, and gave short courses of instruction on nursery techniques and the growing of plants generally at the principal ones.

SYSTEMATIC BOTANY

THE WORK OF THE EAST AFRICAN HERBARIUM

B. Verdcourt, D. M. Napper and M. E. Church

322. Dr. Greenway retired at the end of March after nearly 30 years' service in East Africa. A brief appreciation of his work may be found in Taxon *7*, 69-71 (1958). Mrs. M. E. Church, previously on the staff of the herbarium of the Imperial Forestry Institute, Oxford, joined the staff for four months, which helped very considerably to prevent work accumulating due to Dr. Greenway's retirement. It is unfortunate that a person so well trained in taxonomy could only stay for such a short period. Mr. J. Newbould, who came to East Africa as botanist attached to the Oxford University Tanganyika Expedition, joined the staff in November as a temporary botanist. Administrative work has now become a whole-time task for one person, due largely to the increased volume of correspondence received. Incoming collections for routine naming are also sufficient to fully occupy two botanists and leave little or no time for any research.

323. Routine naming of collections and the supplying of information have continued to take up most of the staff's time. 424 accessions, totalling 9,928 specimens for determination, 2,910 named duplicates and 475 specimens sent to us on loan, have been received. 9,967 specimens have actually been determined. A large number of enquiries concerning poisonous plants have been dealt with. 10,662 specimens have been distributed to other institutions including named duplicates and specimens sent on loan for study.

324. In previous years arrears of naming, mounting and distribution of duplicates have been serious problems. The main problem this year has been the very large accumulation of named mounted sheets awaiting laying away. These totalled 18,403 including 2,621 grasses and sedges. Some progress has been made in getting these incorporated but two thirds still remain. This material has, however, been sorted into families so that they can be included in loans sent away. A further 3,000 named specimens have been mounted but remain unsorted. This laying away will remain a problem since it is a full-time occupation for which little time can be spared at present. It has also been held up by lack

of cupboards. These are now being made and it is hoped that the upper floor of the herbarium will be completely furnished at an early date.

325. Research work has been strictly limited due to lack of time. Miss Napper has worked on ten subfamilies of grasses not treated in the Flora of Tropical Africa, revising the material in the herbarium and producing draft keys. Dr. Verdcourt has described several new species of plants and sent off an account of the family Theaceae for the Flora of Tropical East Africa. The account of the Convolvulaceae remains unpublished and the delay has meant that a great deal of additional material needs adding. The original MS. at Kew will be modified by Dr. Verdcourt during his home leave.

326. During the year several visitors have made use of the herbarium—Mr. Fritz Haerdi and Dr. Moomaw staying several weeks in order to become acquainted with the flora and to name collections.

FIELD WORK

327. Field work has also been limited and only short trips have been possible. In mid-December, 1957, Dr. Verdcourt spent a week with the Mount Kenya I.G.Y. Expedition and Mr. Kirrika Kaya remained with the expedition during the rest of their stay on the mountain. A very useful and interesting collection of plants resulted. Short trips were made to the Tsavo National Park, Lamu, and the Coast Province, Kaptagat, the Mua Hills and Magadi Road; and collections have also been made locally at Muguga and in the Karura Forest. In July, 1958, the Governor invited Dr. Verdcourt to join a safari to Mount Kulal, thus providing a valuable opportunity to visit a rather inaccessible locality. Dr. Verdcourt spent two days in the Mara Game Reserve at the request of Dr. Fraser Darling, who was engaged in a survey. Miss Napper has collected at Machakos, Namanga, Kamakia, Elmenteita, Kitale, Lake Kivu and locally. At the end of the year Miss Napper spent three weeks collecting in Tanganyika, mainly on the Ufipa Plateau, where she obtained many rare plants. Mr. Newbould also travelled to the Mathews and Ndoto Mountains where he made a large collection. Although collecting has been on a limited scale, some interesting plants have been obtained. Mr. Samwell Paulo was loaned to the late Herr Grzimek during part of his survey of the Serengeti Plains. An excellent collection of grasses and other herbs was made.

328. Numerous new taxa have been described during the year from specimens originating from the East African Herbarium and further types have been found; a large number of phototypes have been received from other museums. The number of types previously reported has been found to be erroneous and a recount of actual type specimens (i.e. excluding photographs, fragments of types, etc.) totals 1,021. A start has been made in getting these put into special red covers.

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY

L. D. Verdcourt and D. N. Lazarus

329. The year was broken up into periods when assistance was available in the library and has therefore been a disappointing year in some ways. The routine work has now increased so much that it is almost impossible to complete any of the long-term tasks without further assistance. However, one important job of making a proper alphabetical index of all E.A.V.R.O. standing order periodicals was completed and it is now neat, tidy and easy to check. This had not previously been done since the E.A.V.R.O. library moved here from Kabete.

330. The E.A.V.R.O. Mailing List for Annual Reports and reprints was also revised and retyped in time for the sending out of the 1957 report.

331. Mrs. S. Evans has again been invaluable in working in the library during the librarian's absence on sick leave. During the overlap periods after the librarian's return, various extra jobs were tackled such as the review of old German periodicals with a view to their sale. If approved this scheme should be well worth while and enable us to buy some much needed text books with the proceeds.

332. The new bookbinding scheme is now fully operable and books are being accepted from other High Commission departments. Requests for this service have been received from many libraries, not all of them Government departments, and it is obvious that there is a great need for a bookbinding service in East Africa. Many departments who were previously able to send their binding to the Government Printer are now trying to find another source as the printers are too busy. In the E.A.A.F.R.O./E.A.V.R.O. bookbindery 958 books were bound and 308 pamphlet boxes made during the year. This figure shows that the output is increasing steadily over the years. This work, together with the new High Commission bookbinding service, is the maximum which can be expected from the present staff and with the existing equipment.

333. The financial situation in the library has improved slightly and it is now possible to buy more text books.

334. The Library Committee meets every three or four months to consider requests for additions to the library, and it is hoped to send off three or four indents to the Crown Agents every year.

335. After prolonged discussion and consideration it was decided to buy a microfiche portable reader from England. This has now been ordered and should arrive before the end of the year. It will read both microfilm and microfiche, which is the newest form of microfilm equipment, recording any kind of document on 5 in. × 3 in. film. Up to 32 pages of ordinary-sized books can be recorded on one 5 in. × 3 in. film, which can then be projected on to a desk top or wall. An enormous amount of film can therefore be stored in a vertical filing drawer and indexed normally like books.

336. An adapter lens is fitted to the microfiche reader to take microfilm. Many references are now obtained by the librarian on microfilm and it will be a great boon to have a reader here at Muguga. Positive copies can be made for permanent reference in the laboratory if desired.

337. In December there is to be held a conference of East African librarians at the E.A.A.F.R.O./E.A.V.R.O. Conference Room, Muguga. The librarian will be hostess at the conference and the main library will be the meeting place for librarians from all types of libraries. A bookbinding exhibition will be prepared and the new microfiche reader demonstrated at this time.

EAST AFRICAN AGRICULTURAL JOURNAL

D. W. Duthie

338. Fifty-seven original papers were published in the four issues which appeared during 1958, covering a wide range of subjects including animal husbandry, crop production, entomology, pesticides, land utilization and management, agricultural chemistry, climatology, animal diseases, herbage production and management, water control and utilization, forest pathology and entomology, silviculture, and fisheries research. The number of suitable papers received has increased during the past year or two, and the average size of an issue is over 70 pages. Publication costs have risen

considerably as a result of the increased volume of suitable contributions, and a sharp rise in postal charges has also added to the annual expenditure.

339. At its ninth meeting in February, 1958, the E.A. Agriculture and Fisheries Research Council decided that the annual subscription should be raised from Sh. 10 to Sh. 15 per annum, and this was put into effect with the July issue, volume 24, No. 1. It is too early to judge the effect of this increase on the subscription list and on the revenue, since the majority of annual payments are made in January, but it is hoped that the net result will be some increase in revenue. The three East African Governments have increased their annual subsidies by 50 per cent, but a substantial increase in revenue from subscriptions is also required in order to balance the accounts.

340. One notable feature in this year's issues is the first four sections of Notes on Kenya Agriculture, compiled by the Kenya Department of Agriculture. This series, which will consist of eight or nine sections, is being prepared as a concise handbook of practical agriculture, with particular reference to Kenya but with wide applications in the tropics and subtropics. It will cover crop production, fertilizers, pests and diseases, giving only the salient points in a form which is designed for easy reference.

341. The intensive study of grassland problems is now showing results in a number of papers on this subject, in long range as well as practical aspects of the problems. Animal husbandry is also a leading subject, while papers on forestry and fisheries maintain the wide scope of this Journal.

EAST AFRICAN PLANT QUARANTINE STATION

F. M. L. Sheffield and P. J. Dickinson

342. The scientific supervision given to the Quarantine Station by E.A.A.F.R.O. staff has already been mentioned (page 72). During Mr. Dickinson's absence on long leave from May to November, control of the horticultural work was undertaken by Mr. W. B. May, also a member of the E.A.A.F.R.O. staff.

343. During April, the station was visited by specialists attending the meeting of experts of the Inter-African Phytosanitary Commission held in Nairobi. They expressed general approval of the station and the methods employed; but, if the recommendations

they made on quarantine requirements are accepted by Governments signatory to the Convention, some slight alterations to the buildings will become necessary.

344. Both Dr. Storey and Mr. Dickinson took advantage of leave in England to visit the Quarantine Station at Kew to see the facilities available there and to discuss general quarantine problems. Mr. Dickinson was able also to visit the Experiment Station of the South African Sugar Association at Mount Edgecombe, Natal, and to see the glasshouses at Durban where all cane varieties imported to South Africa during the last 30 years have been kept in quarantine.

Species held in Quarantine during 1958

345. *Banana.* In October the Director of E.A.A.F.R.O. obtained from the Quarantine Station at Kew Gardens suckers of *Giant Cavendish, Gros Michel* and *Lacatan.* The Departments of Agriculture of Kenya, Tanganyika Territory and Uganda are all interested in this importation.

346. *Chrysanthemum.* Work in England has recently shown a large number of viruses may be carried in these ornamentals and produce no symptoms. Many tests by grafting and mechanical inoculation to several indicator species are necessary before a plant can be declared free from all the known viruses. Any one of these viruses is likely to be of potential danger to the pyrethrum industry of Kenya. Others, not yet identified, may well exist in these ornamentals.

347. The East African Standing Technical Committee on Plant Import and Export considered the amount of testing necessary and the time the glasshouses would be occupied to the exclusion of other importations to be out of all proportion to the value of the imported ornamentals, a very small proportion of which have ever survived quarantine in East Africa. They therefore decided to prohibit all further importations.

348. When this decision was taken, a few chrysanthemums were held and some plants of six varieties passed all tests by mechanical inoculation. However, the presence of any one of four of the known viruses would not be demonstrated by these methods. It has been necessary to import an indicator plant, the Mistletoe variety of the ornamental chrysanthemum, from the Ministry of Agriculture's Plant Pathological Laboratories in England. This

variety has now been multiplied so that the six commercially imported varieties can be tested by grafting to it.

349. *Dahlia.* Twenty-three varieties received during 1957 were released to a commercial grower during the first half of 1958.

350. *Maize.* Seed of five early maturing varieties of maize were received in 1957 from India. The seed was sown or grown to maturity, and in 1958 the crop was harvested and sent to the Department of Agriculture in Tanganyika Territory.

351. *Pelargonium.* Some cuttings of a variety with a high oil content were received in such poor condition that all died without rooting.

352. *Pinus radiata.* Scion material from elite trees was received in 1957 and was grafted to local stocks. After a year in quarantine under glass, two plants were released to the Horticulturist, E.A.A.F.R.O., who has undertaken to multiply them on behalf of the Forestry Section.

353. *Strawberries.* Small plants of a climbing variety were recently received from Austria and have been successfully established in the quarantine glasshouses.

354. *Sugar cane.* During the year the East African Standing Technical Committee on Plant Import and Export decided that the period of one year for which cane varieties had in the past been retained at Muguga was insufficient. Two setts of each variety are imported. The plant crop from these is now allowed to mature and is then cut and destroyed. After the variety has been held for a minimum of 18 months in the Muguga glasshouses, the mature ratoon crop is sent to the Experiment Station at Kawanda, Uganda. Before planting at Kawanda, the setts receive heat therapy against ratoon stunting virus. When the plant crop grown in open quarantine is mature, setts are sent to the Departments of Agriculture of Kenya and Tanganyika Territory.

355. Owing to this extension of the quarantine period, no new varieties have been sent to Kawanda during 1958, but the following, imported during 1957, will probably be sent there very soon:—

B.3337, 42231, 47419.
Co.779.
CP.29/116, 44/101.

D.109.

Ebene 1/37.

H.37/1933.

M.31/45, 147/44.

N.10, 50/93, 30/123, 50/211.

POJ.2940.

356. Through the generosity of the Directors of the Sugar Breeding Institute at Coimbatore, India, the Imperial College of Tropical Agriculture, Trinidad, the Bureau of Experiment Stations, Queensland, and the Experiment Station of the S.A. Sugar Association in Natal, the Director of E.A.A.F.R.O. imported the following varieties during 1958:—

B.45151, 49119.

B.O.3, 10, 11, 14.

Co.349, 449, 467, 718, 740, 746, 765, 798, 911, 991, 1001.

Co.S.443, 510.

Q.67, 70.

Trojan.

357. We have been obliged to destroy the following varieties in quarantine:—

B.O.3 (one sett only destroyed), 10, 11.

Co.467 (reimported), 680, 684.

358. A collection has been kept at Muguga of all the cane varieties that have passed through quarantine there. This collection was sited in the quarantine enclosure but it was felt that its proximity offered some slight risk should a bacterial disease, for example, be imported and escape from the houses. The collection has therefore been removed to an enclosure adjacent to the E.A.A.F.R.O. laboratories and about a mile away from the quarantine station.

359. *Sweet potatoes.* Three tubers of a variety imported by the Kenya Department of Agriculture were found to be virus infected and were destroyed.

Species quarantined from 1954–8

360. Now that the station has been in operation for five years, it may be appropriate to mention the numbers of species and varieties handled during that time. We have received:—

Species	Nos. of Varieties		Held Dec., 1958	Sources
	Received	Released		
*Agathis	1	—	—	New Guinea.
Banana	3	—	3	U.K.
Begonia	22	1	—	France, U.K.
Chrysanthemum ..	53	5	7	Holland, U.K.
Coffee	1	1	—	U.S.A.
Cynodon dactylon	2	2	—	Rhodesia.
Dahlia	57	36	—	Holland, U.K.
Maize	5	5	—	India.
*Pelargonium ..	1	—	—	Algeria via France.
Pine	5	2	—	Australia.
*Shallot	1	—	—	Ghana.
†Sugar Cane ..	85	43	38	Australia, India, Mauritius, S. Africa, Trinidad.
Strawberry	1	—	1	Austria.
Sweet potato ..	2	1	—	India, S. Africa.
Symphytum sp. ..	1	1	—	U.K.

* Plants received in such poor condition that it was impossible to establish them in quarantine.

† Six varieties have been totally destroyed and two of these have been reimported.

361. The table does not indicate the numbers of infected plants intercepted, as when several plants of a variety are introduced some may be infected whilst others can be released. So far 54 new varieties of economic plants and 42 ornamentals have been released to East African growers, whilst 42 varieties of food plants and seven ornamentals are at present held at Muguga. Sugar cane remains the chief importation, but the station is being used for an increasing number of species by the Department of Agriculture both for their own use and at the request of commercial firms.

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